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At 5°C, in nonbuffered purified water (reasonably analogous to ROWPU-treated water) at

pH 9.0, 1 mg/L of free chlorine (FC) inactivated 99.99% of poliovirus 1 in 110 minutes and

5 mg/L of FC inactivated 99.99% of the virus in about 27 minutes. If tailing occurs (and it

usually does) a margin of safety must be added to a treatment standard for this alone. And

since there are undoubtedly enteric viruses more FC-resistant than the poliovirus used in

these studies, the military treatment standard of 5 mg/L for 30 minutes at any temperature

and any pH may be inadequate for ROWPU-treated water.

At 5°C, 526 mg/L of KCl (250 mg/L Cl⁻, a level far below the military's 600 mg/L

permissible maximum for drinking water) potentiated the inactivation by FC at pH 9.0 of

poliovirus 1 in nonbuffered purified water. In nonbuffered purified water, 526 mg/L of

KCl increased the polioviral effectiveness of FC by 700%. Under the same circumstances,

1,262 mg/L (600 mg/L Cl⁻, the maximum level acceptable by the military for drinking water)

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increased the poliocidal effectiveness of FC by 1400%.

At 5°C, poliovirus 1 was inactivated by FC at pH 9.0 more than 9 times more rapidly in nonbuffered tap water than in non-buffered purified water suggesting that KCl with or without other ions in tap water potentiated the virucidal effectiveness of FC.

Potassium chloride did not potentiate the poliocidal effectiveness of FC at pH 9.0 to nearly the degree in nonbuffered tap water that it did in non-buffered purified water suggesting that ions present in tap water potentiated the virucidal effectiveness of FC.

FC inactivated poliovirus 1 at pH 9.0 more than 3 times more rapidly in borate-buffered (0.05M) purified water than in nonbuffered purified water suggesting that the buffer ions potentiated the virucidal effectiveness of the FC. Clearly, disinfection studies should not be done in buffers without first determining the virucidal potentiating effect of the buffers.

Potassium chloride potentiated the virucidal effectiveness of FC in 0.05 M borate buffer to a lesser degree than in nonbuffered purified water further indicating that buffer ions potentiated the virucidal effectiveness of FC and that a maximum ion effect exists.

Potassium chloride, at a level 1, 262 mg/L, potentiated the virucidal effectiveness of FC at pH 4.5 in phthalate-buffered purified water, but to a lesser degree than it potentiated the virucidal effectiveness of FC at pH 9.0 in borate-buffered purified water.

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**EFFECT OF POTASSIUM CHLORIDE ON THE VIRUCIDAL EFFECTIVENESS
OF CHLORINE DISINFECTION FOR MILITARY NEEDS**

FINAL PHASE I REPORT

Gerald Berg, Ph.D.

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**EFFECT OF POTASSIUM CHLORIDE ON THE VIRUCIDAL EFFECTIVENESS
OF CHLORINE DISINFECTION FOR MILITARY NEEDS**

SUMMARY

1. At 5°C, in nonbuffered purified (carbon-filtered, deionized) water (reasonably analogous to ROWPU-treated water) at pH 9.0, 1 mg/L of free chlorine (FC) inactivated 99.99% of poliovirus 1 in 110 minutes, and 5 mg/L of FC inactivated 99.99% of the virus in about 27 minutes. If tailing occurs (and it usually does) a margin of safety must be added to a treatment standard for this alone. And since there are undoubtedly enteric viruses more FC-resistant than the poliovirus used in these studies, the military treatment standard of 5 mg/L for 30 minutes at any temperature and any pH may be inadequate for ROWPU-treated water.
2. At 5°C, 526 mg/L of KCl (K^+ -276 mg/L, Cl^- -250 mg/L) (a level of Cl^- far below the military's 600 mg/L permissible maximum for drinking water) potentiated the inactivation by FC at pH 9.0 of poliovirus 1 in nonbuffered purified water. In nonbuffered purified water, 526 mg/L of KCl increased the poliocidal effectiveness of FC by 700%. Under the same circumstances, 1,262 mg/L of KCl (K^+ -662 mg/L, Cl^- -600 mg/L) (the maximum level of Cl^- acceptable by the military for drinking water) increased the poliocidal effectiveness of FC by 1,400%.
3. At 5°C, poliovirus 1 was inactivated by FC at pH 9.0 more than 9 times more rapidly in nonbuffered tap water than in nonbuffered purified water suggesting that salts or their ions in tap water potentiated the virucidal effectiveness of the FC.
4. Potassium chloride did not potentiate the poliocidal effectiveness of FC at pH 9.0 to nearly the degree in nonbuffered tap water that it did in nonbuffered purified water suggesting that salts or ions present in tap water potentiated the virucidal effectiveness of FC.
5. FC inactivated poliovirus 1 at pH 9.0 more than 3 times more rapidly in borate (boric acid [H_3BO_3])[0.05M]-NaOH buffered purified water than in nonbuffered purified water suggesting that the buffer ions potentiated the virucidal effectiveness of the FC. Clearly, disinfection studies should not be done in buffers without first determining the virucide potentiating effect of the buffers.
6. Potassium chloride potentiated the virucidal effectiveness of FC in H_3BO_3 (0.05 M)-NaOH buffer to a lesser degree than in nonbuffered purified water indicating that the buffer or its ions potentiated the virucidal effectiveness of FC and that a maximum ion effect exists.
7. Potassium chloride, at a level of 1,262 mg/L (K^+ -662 mg/L, Cl^- -600 mg/L), potentiated the virucidal effectiveness of FC at pH 4.5 in phthalate-buffered purified water but to a lesser degree than it potentiated the virucidal effectiveness of FC at pH 9.0 in H_3BO_3 (0.005 M)-NaOH buffered purified water.

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EFFECT OF POTASSIUM CHLORIDE ON THE VIRUCIDAL EFFECTIVENESS OF CHLORINE DISINFECTION FOR MILITARY NEEDS

INTRODUCTION

The military looks to disinfection with free chlorine (FC) as the final barrier to prevent viruses and other pathogenic microorganisms from producing disabling enteric diseases in military personnel who must drink field-produced drinking water. The disinfection barrier is paramount in all of the variety of conditions under which the military must produce drinking water in the field.

It has been demonstrated repeatedly that in the presence of 0.05 to 0.1M (3,728 to 7,456 mg/L) KCl (because KCl is completely ionized in water, KCl exists as K^+ and Cl^-) hypochlorite ion (OCl^-), the otherwise slow virucidal form of FC, is 10 to 20 times more virucidal than hypochlorous acid ($HOCl$), the rapid virucidal form of FC (1-6). The virucidal activity of $HOCl$ also is potentiated by KCl. It is not clear whether K^+ or Cl^- or both is responsible for the potentiation. (It is now clear from the research reported herein that many ions in drinking water potentiate the virucidal effectiveness of FC.) The occurrence of K^+ and/or Cl^- in a drinking water, if present in sufficient concentration, may potentiate the virucidal effectiveness of the free chlorines. Conversely, removal of these entities from a drinking water may significantly reduce the virucidal effectiveness of the free chlorines. The range of Cl^- concentrations in natural water may span from only 10 or 20 mg/L (fresh water treated with Reverse Osmosis Water Purification Units [ROWPU]) to 600 mg/L (field water quality standard maximum). Potassium ions also occur in natural waters in low concentrations, and there is no field water quality maximum standard for these ions. Reverse osmosis removes most K^+ , Cl^- , and other ions from water. Thus, ROWPU may reduce the virucidal effectiveness of the FC applied to such treated waters to prevent post ROWPU treatment microbiological contamination. In this situation, it might be necessary for the military to increase the concentration of FC in the field-disinfected waters to meet the military's required disinfection standards. It was therefore of considerable importance to the military to determine the effect of small concentrations of ions on the virucidal capability of FC (OCl^- and $HOCl$).

This study was divided into two phases, PHASE 1 was to determine whether KCl (Cl^- in the range of 10 to 600 mg/L) has a significant effect (2 to 3-fold difference) on disinfection by the free chlorines. In the event that a significant KCl effect was demonstrated, PHASE 2 was to be initiated to provide comprehensive data on the adjustment of FC that will be necessary to meet the military's required disinfection capability or to develop cautionary guidance for field disinfection at low K^+ and/or Cl^- levels (for example, ROWPU operations). *Keywords: Reverse Osmosis Water Purification Unit (ROWPU); Drinking water; (x)*

MATERIAL AND METHODS

1. Water.

All of the disinfection tests were done in chlorine demand-free purified (carbon-filtered, deionized) water, in tap water obtained in the City of Cincinnati, or in buffers prepared in those waters. Purified water was obtained from a Millipore Super Q System.

2. Phosphate buffer.

A 0.2 M phosphate buffer solution was prepared by adding 23.7 g of KH_2PO_4 (Fisher P-382) and 4.2 g of K_2HPO_4 (Fisher P-288) to 1 L of purified water. This solution was filtered through a 0.45 μm Millipore membrane. A 0.05 M phosphate buffer solution was prepared by adding 250 mL of 0.2 M phosphate buffer to 750 mL of purified water.

3. Sodium thiosulfate neutralizer solution.

A 100 mg/mL solution of $\text{Na}_2\text{S}_2\text{O}_3$ was prepared by adding 12.5 g of $\text{Na}_2\text{S}_2\text{O}_3$ (Fisher S-446) to 125 mL of purified water. One mL of this solution was added to 1 L of 0.05 M phosphate buffer to yield a 100 mg/L solution of $\text{Na}_2\text{S}_2\text{O}_3$ in phosphate buffer.

4. Beef extract (1%).

A 1% solution of beef extract was prepared by adding 10 g of beef extract (Gibco M00040) to 1 L of purified water. This solution was used for preparing dilutions of virus.

5. Chlorine demand-free waters.

Chlorine demand-free waters were prepared according to Standard Methods (7). Waters, purified and tap, were made demand-free by chlorinating them to a free residual of 5 mg/L and storing them for three days. The waters were then dechlorinated by exposure to ultraviolet light for several days. To make certain that no chlorine remained in the waters, amperometric titrations were performed on them when chlorine was no longer demonstrable by DPD test. The demand-free dechlorinated waters were stored until needed.

6. Chlorine demand-free buffers.

a. Phthalate buffer. Phthalate buffer was prepared by adding 40.846 g of potassium hydrogen phthalate to 1 L of purified water. The molarity was 0.2 M. Chlorine was added to the buffer to a final concentration of 5 mg/L. The chlorinated buffer was stored in the laboratory for three days to satisfy the chlorine demand, and the buffer was dechlorinated by exposing it to ultraviolet light. To make certain that no chlorine remained, amperometric titrations were performed on the buffer when chlorine was no longer demonstrable by the DPD test. For tests, the 0.2 M buffer was diluted in chlorine demand-free purified water to 0.005 M and its pH was adjusted to 4.5 with chlorine demand-free 2 M H_2SO_4 or NaOH.

b. Borate buffer. Borate buffer was prepared by adding 12.366 g of boric acid to 1 L of purified water. The molarity was 0.2. The buffer was made chlorine demand-free and its pH was adjusted in the same way that this was done with the phthalate buffer.

7. Chlorine demand-free NaOH and chlorine demand-free H_2SO_4 .

Appropriate strength solutions of NaOH and H_2SO_4 were prepared and made chlorine demand-free in the same way that the buffers were made demand-free.

8. Chlorine demand-free KCl solution.

KCl (Matheson, Coleman, and Bell PX1405) solutions were prepared in three concentrations as follows: A solution containing 21 mg of KCl/10 mL was prepared by dissolving 0.21 g of KCl in 100 mL of purified water. A solution containing 526 mg of KCl/10 mL was prepared by dissolving 5.26 g of KCl in 100 mL of purified water. A solution

containing 1,262 mg of KCl/10 mL was prepared by dissolving 12.62 g of KCl in 100 mL of purified water. All of the solutions were prepared in volumetric flasks and all of the solutions were brought to final volume with a few drops of chlorine solution of sufficient strength to yield about 5 mg/L of chlorine. The solutions were made chlorine demand-free in the same way the buffers were made demand-free. In the test procedures, 4 mL of KCl solution added to 396 mL of test solution yielded the required concentration of Cl⁻.

9. Chlorine demand-free glassware.

Chlorine demand-free glassware was prepared by the procedure described in Standard Methods (7). Chlorine demand-free beakers and cylinders used in the test procedures were rinsed three times in the test waters just before the tests were done.

10. Amperometric titrations for FC.

Amperometric titration with phenylarsene oxide for FC were done by the procedures described in Standard Methods (7). The titrations were done on a total volume of 300 mL of each test fluid.

11. Virus.

A chlorine demand-free preparation of poliovirus 1 (Mahoney LP, RKP42 of 10/7/69) was used in all of the experiments described herein.

12. Cell cultures. All poliovirus assays were done in BGM cells (8) by the plaque technique (9). Plaques were generally read 3, 4, and 7 days after cultures were inoculated.

13. Test procedure.

One-and-a-half to two-liter quantities of chlorine demand-free water, sometimes buffered, sometimes not, sometimes purified water, sometimes tap water, were chlorinated to either 1 or 5 mg/L residuals, and 396 mL quantities were distributed into 600 mL beakers. Four mL of an appropriate concentration of KCl solution was added to each of three beakers to yield concurrently K⁺ plus Cl⁻ concentrations of 11 and 10, 276 and 250, and 662 and 600 mg/L. In many of the tests, phthalate buffer was used to maintain a pH of 4.5 and borate buffer was used to maintain a pH of 9.0. When buffers were not used, the pH of each test water was adjusted with 2 M and 0.25 M H₂SO₄ or NaOH, respectively, and rechecked and readjusted if necessary at the beginning of each test. Two control beakers were set up with each test. In most experiments, one contained 396 mL of the test water to which had been added 4 mL of KCl solution of sufficient strength to yield a final concentration of 662 mg/L of K⁺ and 600 mg/L of Cl⁻ in the control beaker. The second beaker contained 198 mL of the test water, 198 mL of Na₂S₂O₃ neutralizer solution and 4 mL of KCl solution of sufficient strength to yield a final concentration of 662 mg/L of K⁺ and 600 mg/L of Cl⁻ in the control beaker. Test and control waters were brought to 50°C (± 1°C) in a water bath, and under continuous stirring on a magnetic stirrer, 1 mL of a chlorine demand-free poliovirus 1 suspension was added to each beaker. Five mL samples were removed from each test beaker at appropriate time intervals and mixed rapidly with 5 mL volumes of a solution that contained 100 mg/L of Na₂S₂O₃. A similar sampling procedure was used for the control beakers, but the first control beaker was sampled only after one minute, and the second control beaker was sampled at the longest time interval used in any of

the tests. In tests where nonbuffered systems were used, pH was redetermined in each test beaker at the conclusion of each test. Amperometric titrations for FC were also done on all test fluids at the conclusion of each test. All test samples were diluted in 1% beef extract and inoculated onto cell cultures. Some test samples were stored at -70°C for several days before inoculation onto cell cultures. Control tests showed that freezing test samples at -70°C before inoculation onto cell cultures did not alter results.

RESULTS

The first year of this study was devoted to determining whether KCl, at levels of up to 1,262 mg/L (K^+ -662 mg/L; Cl^- -600 mg/L [the maximum Cl^- level permissible for drinking water under Military standards]) significantly increases the rate of inactivation of poliovirus by FC at pH 4.5 and at pH 9.0. Early experiments were undertaken at pH 10.0 to maximize the OCl^- levels present, and many of the preliminary studies were done at this pH level. At the request of the Project Officer, the pH of the alkaline level tests was reduced to 9.0, because this pH level is more in line with the higher extremes usually experienced under field conditions. The data obtained at pH 10.0 are presented in Appendices C and D.

In early experiments in 0.05 M borate buffer, more than 7,456 mg/L of KCl (0.1 M) did not affect the rate of inactivation of poliovirus 1 by FC at pH 10.0. Several lots of sodium and potassium chloride from different manufacturers yielded results similar to those in these earlier studies, but lots of boric acid (a buffer component) from manufacturers other than the one used in the first studies allowed a salt effect to manifest itself.

In borate buffer that allowed manifestation of a salt effect, 526 and 1,262 mg/L quantities of KCl (K^+ -276 and 662 mg/L, respectively; Cl^- -250 and 600 mg/L, respectively) increased the rate of poliovirus 1 inactivation by FC at pH 9.0.

Inactivation of Poliovirus 1 in Phthalate-Buffered Purified Water, pH 4.5

In phthalate buffered purified water at pH 4.5, where most of the FC exists as $HOCl$, 1.17 mg/L of FC, in the absence of KCl, inactivated 99.99% of poliovirus 1 in just over 4.0 minutes (Table 1, Figure 1). In the presence of 21 mg/L of KCl (K^+ -11 mg/L; Cl^- -10 mg/L), approximately the same quantity of FC inactivated poliovirus 1 at about the same rate, and in the presence of 526 mg/L of KCl, a little bit more rapidly. In the presence of 1,262 mg/L of KCl, however, 0.97 mg/L of FC inactivated 99.99% of poliovirus 1 in about 2.8 minutes.

In phthalate-buffered purified water at pH 4.5, 5.27 mg/L of FC, in the absence of KCl, inactivated 99.99% of poliovirus 1 in about 1.2 minutes. The same quantity of FC in the presence of 21 mg/L of KCl inactivated poliovirus 1 at about the same rate. In the presence of 526 mg/L of KCl, 5.20 mg/L of FC inactivated poliovirus 1 a little more rapidly, and in the presence of 1,262 mg/L of KCl, 5.15 mg/L of FC inactivated poliovirus 1 twice as rapidly as the same quantity of FC did in the absence of KCl (Table 2, Figure 2).

Inactivation of Poliovirus 1 in Borate-Buffered Purified Water, pH 9.0

In borate-buffered purified water at pH 9.0, 1.22 mg/L of FC (primarily OCl^-), in the absence of KCl, inactivated 99.99% of poliovirus 1 in about 22 minutes. In the presence of 21 mg/L of KCl, the rate of inactivation of poliovirus 1 by 1.16 mg/L of FC was about the same. In the presence of 526

mg/L of KCl, 99.99% of the virus was inactivated by 1.14 mg/L of FC in about 16 minutes, and in the presence of 1,262 mg/L of KCl, 1.20 mg/L of FC inactivated 99.99% of the virus in about 10 minutes (Table 3, Figure 3).

In another experiment in the same buffer, in the absence of KCl, 1.08 mg/L of FC inactivated 99.99% of poliovirus 1 in 22 minutes. In the presence of 21 mg/L of KCl, 1.05 mg/L of FC inactivated the virus at about the same rate. In the presence of 526 mg/L of KCl, 1.04 mg/L of FC inactivated 99.99% of the virus in about 18 minutes. In the presence of 1,262 mg/L of KCl, however, 1.01 mg/L of FC inactivated 99.99% of the virus in about 12 minutes (Table 4, Figure 4).

In the same buffer, 5.05 mg/L of FC, in the absence of KCl, inactivated 99.99% of poliovirus 1 in about 9.5 minutes. In the presence of 21 mg/L of KCl, 5.00 mg/L of FC inactivated the poliovirus at about the same rate. In the presence of 526 mg/L of KCl, 5.05 mg/L of FC inactivated 99.99% of the virus in about 3.5 minutes, and in the presence of 1,262 mg/L of KCl, 5.00 mg/L of FC inactivated 99.99% of the virus in about 2.2 minutes (Table 5, Figure 5).

Inactivation of Poliovirus 1 in Borate-Buffered Tap Water, pH 9.0

In borate-buffered tap water at pH 9.0, 5.20 mg/L of FC, in the absence of KCl, inactivated 99.99% of poliovirus 1 in about 3.6 minutes. In the presence of 21 mg/L of KCl, 5.17 mg/L of FC inactivated the poliovirus at about the same rate. In the presence of 526 mg/L of KCl, 5.10 mg/L of FC inactivated 99.99% of the virus in about 2.7 minutes, and in the presence of 1,262 mg/L of KCl, 5.00 mg/L of FC inactivated 99.99% the virus in about 2.3 minutes (Table 6, Figure 6).

Inactivation of Poliovirus 1 in Nonbuffered Purified Water, pH 9.0

In nonbuffered purified water at pH 9.0, 0.95 mg/L of FC, in the absence of KCl, inactivated 99.99% of poliovirus 1 in a little more than 100 minutes. In the presence of 21 mg/L of KCl, 0.93 mg/L of FC inactivated 99.99% of the virus in about 63 minutes. In the presence of 526 mg/L of KCl, 0.90 mg/L of FC inactivated 99.99% of the poliovirus in about 18 minutes, and in the presence of 1,262 mg/L of KCl, 0.85 mg/L of FC inactivated 99.99% of the virus in about 5 minutes (Table 7, Figure 7).

In the same nonbuffered system, 5.00 mg/L of FC, in the absence of KCl, inactivated 99.99% of poliovirus 1 in 23 to 24 minutes. In the presence of 21 mg/L of KCl, 5.00 mg/L of FC inactivated the virus at about the same rate. In the presence of 526 mg/L of KCl, 4.88 mg/L of FC inactivated 99.99% of the poliovirus in about 4.5 minutes, and in the presence of 1,262 mg/L of KCl, 4.83 mg/L of FC inactivated 99.99% of the poliovirus in about 2.5 minutes (Table 8, Figure 8).

In another series of tests, in the same nonbuffered system, 5.00 mg/L of FC, in the absence of KCl, inactivated 99.99% of poliovirus 1 in about 31 minutes. In the presence of 21 mg/L of KCl, 5.05 mg/L of FC inactivated the poliovirus at about the same rate. In the presence of 526 mg/L of KCl, 4.95 mg/L of FC inactivated 99.99% of the virus in about 3 minutes, and in the presence of 1,262 mg/L of KCl, 5.00 mg/L of FC inactivated 99.99% of the virus in about 2 minutes (Table 9, Figure 9).

Inactivation of Poliovirus 1 in Nonbuffered Tap Water, pH 9.0

In nonbuffered tap water at pH 9.0, 0.35 mg/L of FC, in the absence of KCl, inactivated 99.99% of poliovirus 1 in about 13 minutes. In the presence of 21 mg/L of KCl, 1.02 mg/L of FC inactivated 99.99% of the virus in about 13 minutes. In the presence of 526 mg/L of KCl, 1.00 mg/L of FC inactivated 99.99% of the poliovirus in about 9 minutes, and in the

presence of 1,262 mg/L of KCl, 1.02 mg/L of FC inactivated 99.99% of the virus in 4 to 5 minutes (Table 10, Figure 10).

In the same nonbuffered tap water system, 5.00 mg/L of FC, in the absence of KCl, inactivated 99.99% of poliovirus 1 in about 3 minutes. In the presence of 526 mg/L of Cl⁻, 4.85 mg/L of FC inactivated 99.99% of the poliovirus in 2 to 2.5 minutes, and in the presence of 1.62 mg/L of KCl, 4.80 mg/L of FC inactivated 99.99% of the virus in just under 2 minutes (Table 11, Figure 11).

DISCUSSION

At pH 4.5 in phthalate buffer, FC inactivated poliovirus 1 about 80% more rapidly in the presence of 1,262 mg/L of KCl than in the absence of KCl (Figures 1, 2, and 12). Potassium chloride, at a level of 526 mg/L, also appeared to potentiate the poliocidal effectiveness of FC at pH 4.5, but to a lesser degree. At a level of 21 mg/L, KCl did not appear to significantly potentiate FC at pH 4.5 in phthalate buffer or under any of the other conditions subsequently tested. The potentiation of FC by KCl in buffer at pH 4.5 is clearly worthwhile, but HOCl, the predominant form of FC that occurs at pH 4.5, is a rapid virucide even in the absence of KCl. The military's greatest need is on the alkaline side of the pH spectrum because OCl⁻, which forms at alkaline pH levels as the result of the ionization of HOCl, is a relatively slow virucide and because most natural waters are alkaline. At pH 9.0 in borate buffer, FC inactivated poliovirus 1 almost three times more rapidly in the presence of 1,262 mg/L of KCl than in the absence of KCl (Figures 3-5, and 13). Potassium chloride, at a level of 526 mg/L, potentiated the poliocidal effectiveness of FC by almost 2-fold.

At pH 9.0, in the presence of 1,262 mg/L of KCl, FC inactivated poliovirus 1 as rapidly in tap water as in borate-buffered purified water (compare Figures 6 and 13). In the absence of KCl, however, FC inactivated the poliovirus 1 considerably more rapidly in tap water than in borate-buffered purified water. This finding, along with the earlier finding that different commercial preparations of H₃BO₃ (the major component of borate buffer), differently affected the poliocidal effectiveness of FC, strongly suggested a need for testing the virucidal effectiveness of FC (with and without KCl) in nonbuffered purified water. Buffers have always been used to maintain pH at required levels. Preliminary studies, however, showed that pH levels in purified water, adjusted with H₂SO₄ or NaOH, remained stable for long periods within 0.1 (occasionally 0.2) pH units. Subsequent studies in nonbuffered waters produced remarkable results.

In studies with nonbuffered purified water at pH 9.0, FC inactivated poliovirus 1 about 15 times more rapidly in the presence of 1,262 mg/L of KCl than in the absence of KCl. In the presence of 526 mg/L of KCl, FC inactivated the virus about 7 times more rapidly than in the absence of KCl (Figures 7-9, 14). In the presence of 526 and 1,262 mg/L of KCl, FC inactivated the poliovirus about as rapidly in nonbuffered purified water as in borate-buffered purified water (Figures 13 and 14). But in the absence of KCl, FC inactivated the virus more than 3 times faster in the borate-buffered purified water than in the nonbuffered purified water (Figure 15 - from Figures 13 and 14). The 0.05 M borate buffer had a powerful virucide potentiating effect on FC. It is clear that disinfection studies should not be done in buffers without first determining the virucide potentiating effect of the buffers. The borate buffer did not add to potentiation in the presence of either 526 or 1,262 mg/L of KCl.

The experiments in Figures 10 and 11 are exactly the same as those in Figures 7-9 and 14 except that in Figures 10 and 11 the experiments were done in nonbuffered tap water and those in Figures 7-9 and 14 were done in nonbuffered purified water. When 1,262 mg/L of KCl was present, the virucidal effectiveness of FC at pH 9.0 was not much different in nonbuffered purified water than in nonbuffered tap water. When 526 mg/L of KCl was present in both waters, the inactivation rate was faster in tap water than in purified water, and when no KCl was present, the inactivation rate dropped off sharply in purified water. In the absence of KCl, poliovirus 1 was inactivated by FC about 10 times more rapidly in nonbuffered tap water than in nonbuffered purified water (Figure 17). It would appear that ions in the tap water markedly enhanced the poliocidal effectiveness of OCl^- .

Since RO-treated waters contain few ions, the poliocidal effectiveness of OCl^- in such waters will be about that seen in the nonbuffered purified water study. This is to say that in RO-treated waters at pH 9.0, about 110 minutes will be required to inactivate 99.99% of poliovirus 1 at 50°C by 1 mg/L of FC (about the same as in nonbuffered purified water), and 27 minutes will be required to inactivate 99.99% of the virus by 5 mg/L of FC under the same conditions (Figure 17). If tailing occurs (and it usually does because naturally occurring viruses are usually clumped to some degree) as it frequently did in the experiments reported herein, a margin for safety must be added to a treatment standard for this alone. And, since there are undoubtedly enteric viruses more FC-resistant than the poliovirus used in these studies, the military treatment standard of 5 mg/L for 30 minutes at any temperature and any pH may be inadequate for ROWPU-treated waters and other drinking waters with low ionic content.

For waters that contain a sufficient quantity of ions, the treatment standard may be excessive. But, we must know more than we do now about the relationship of ion concentration and FC inactivation rates and more about the levels of salts present in such waters before we can say that with assurance.

Although, it seems clear now that many different ions may potentiate the poliocidal effectiveness of HOCl and OCl^- , we know little about which ions do so. Moreover, even though at least one theory suggests that cations rather than anions are responsible for the enhanced poliocidal effectiveness of HOCl and OCl^- (4,10,11), even this is not yet certain.

CONCLUSIONS AND RECOMMENDATIONS

In PHASE 1 of this study, we showed that an enhancement of poliocidal activity by FC occurs at the salt levels present in natural waters. This study also showed that tap water contains substances (probably ions) that enhance the virucidal activity of FC (both HOCl and OCl^-). Potassium chloride levels of 526 mg/L and 1,262 mg/L potentiated the virucidal effectiveness of FC. In purified water, KCl potentiated the virucidal capability of OCl^- by 10-fold and sometimes more. In the absence of salts, 5 mg/L of FC at pH 9.0 inactivated poliovirus 1 so slowly in purified water, it may be necessary for the military to adjust the dosage of FC in order to meet its required disinfection capability in ROWPU-treated waters and in other waters of low salt content.

Thus, the military needs to pursue PHASE 2 of this study to determine the degree to which the ion effect occurs with viruses other than poliovirus 1 and to determine which ions potentiate the virucidal effectiveness of FC. With this information, the military will be better

able to decide whether it must adjust the dosage of FC in field-produced drinking waters such as ROWPU-treated waters and other waters of low ion content in order to meet the military's required disinfection capability.

Moreover, to the extent that FC concentrations can be reduced in waters that contain ions that potentiate the virucidal effectiveness of FC, the production of carcinogenic halomethanes will be reduced. Although the problems produced by such carcinogens may not be manifested for many years and are therefore of no battlefield significance, eventual consequences of the kind currently experienced with the agent orange situation, and the accompanying negative public relations, are always better avoided.

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APPENDIX A
(LIST OF TABLES [pH 4.5 and 9.0])

TABLE 1. INACTIVATION OF POLIOVIRUS 1 AT 5°C IN PHTHALATE-BUFFERED
PURIFIED WATER AT PH 4.5 BY APPROXIMATELY 1 MG/L
OF FREE CHLORINE IN THE PRESENCE & ABSENCE OF KCL

TEST #1 CHLORINE (MG/L): 1.17 KCL (MG/L): 0 CONTROL (PFU/ML): 250000
INITIAL CHLORINE (MG/L): 1.22

TIME (MIN.)	SAMPLE 1 (PFU/ML)	SAMPLE 2 (PFU/ML)	AVERAGE (PFU/ML)	SURVIVAL (%)	INACTIVATION (%)
.5	48000	28000	38000	15.1999	84.8001
1	20400	15200	17800	7.1199	92.8801
1.5	10800	6400	8600	3.44	96.56
2	5200	4000	4600	1.8399	98.1601
2.5	840	840	840	.336	99.664
3	320	248	284	.1136	99.8864
3.25	104	136	120	.0479	99.9521
3.5	132	116	124	.0495	99.9505
3.75	60	28	44	.0175	99.9825
4	4	16	10	4E-03	99.996

TEST #2 CHLORINE (MG/L): 1.11 KCL (MG/L): 21 CONTROL (PFU/ML): 250000
INITIAL CHLORINE (MG/L): 1.22

TIME (MIN.)	SAMPLE 1 (PFU/ML)	SAMPLE 2 (PFU/ML)	AVERAGE (PFU/ML)	SURVIVAL (%)	INACTIVATION (%)
.5	22400	24800	23600	9.44	90.56
1	12800	14800	13800	5.5199	94.4801
1.5	8000	6800	7400	2.9599	97.0401
2	8800	8000	8400	3.36	96.64
2.5	2080	2280	2180	.8719	99.1281
3	680	1040	860	.344	99.656
3.25	360	400	380	.152	99.848
3.5	236	252	244	.0976	99.9024
3.75	140	172	156	.0623	99.9377
4	72	68	70	.0279	99.9721

TABLE 1. (CONTINUED)

TEST #3 CHLORINE (MG/L): 1 KCL (MG/L): 526 CONTROL (PFU/ML): 250000
 INITIAL CHLORINE (MG/L): 1.22

TIME (MIN.)	SAMPLE 1 (PFU/ML)	SAMPLE 2 (PFU/ML)	AVERAGE (PFU/ML)	SURVIVAL (%)	INACTIVATION (%)
.5	6400	9200	7800	3.12	96.88
1	5200	4400	4800	1.9199	98.0801
1.5	1400	1520	1460	.584	99.416
2	1000	640	820	.3279	99.6721
2.5	480	400	440	.1759	99.8241
3	216	176	196	.0783	99.9217
3.25	132	128	130	.0519	99.9481
3.5	88	68	78	.0311	99.9689
3.75	32	32	32	.0128	99.9872
4	8	8	8	3.2E-03	99.9968

TEST #4 CHLORINE (MG/L): .97 KCL (MG/L): 1,262 CONTROL (PFU/ML): 250000
 INITIAL CHLORINE (MG/L): 1.22

TIME (MIN.)	SAMPLE 1 (PFU/ML)	SAMPLE 2 (PFU/ML)	AVERAGE (PFU/ML)	SURVIVAL (%)	INACTIVATION (%)
.5	6400	2800	4600	1.8399	98.1601
1	3600	3600	3600	1.4399	98.5601
1.5	280	280	280	.1119	99.8881
2	216	172	194	.0775	99.9225
2.25	172	172	172	.0688	99.9312
2.5	80	88	84	.0335	99.9665
2.75	56	40	48	.0192	99.9808
3	32	16	24	9.6E-03	99.9904
3.25	8	12	10	4E-03	99.996
3.5	0	0	0	< 0.0001	> 99.9999

TABLE 2. INACTIVATION OF POLIOVIRUS 1 AT 5°C IN PHTHALATE-BUFFERED
PURIFIED WATER AT PH 4.5 BY APPROXIMATELY 5 MG/L
OF FREE CHLORINE IN THE PRESENCE & ABSENCE OF KCL

TEST #1 CHLORINE (MG/L): 5.27 KCL (MG/L): 0 CONTROL (PFU/ML): 128000
INITIAL CHLORINE (MG/L): 5.3

TIME (MIN.)	SAMPLE 1 (PFU/ML)	SAMPLE 2 (PFU/ML)	AVERAGE (PFU/ML)	SURVIVAL (%)	INACTIVATION (%)
.25	1640	1320	1480	1.1562	98.8438
.5	1080	440	760	.5937	99.4063
.75	88	64	76	.0593	99.9407
1	4	3	6	4.6E-03	99.9954
1.25	0	4	2	1.5E-03	99.9985
1.5	0	0	0	< 0.0001	> 99.9999
1.75	0	0	0	< 0.0001	> 99.9999
2	4	4	4	3.1E-03	99.9969
2.25	0	0	0	< 0.0001	> 99.9999
2.5	0	0	0	< 0.0001	> 99.9999

TEST #2 CHLORINE (MG/L): 5.25 KCL (MG/L): 21 CONTROL (PFU/ML): 128000
INITIAL CHLORINE (MG/L): 5.3

TIME (MIN.)	SAMPLE 1 (PFU/ML)	SAMPLE 2 (PFU/ML)	AVERAGE (PFU/ML)	SURVIVAL (%)	INACTIVATION (%)
.25	1400	1160	1280	1	99
.5	440	480	460	.3593	99.6407
.75	120	108	114	.089	99.911
1	36	8	22	.0171	99.9829
1.25	0	0	0	< 0.0001	> 99.9999
1.5	0	0	0	< 0.0001	> 99.9999
1.75	0	0	0	< 0.0001	> 99.9999
2	0	0	0	< 0.0001	> 99.9999
2.25	0	0	0	< 0.0001	> 99.9999
2.5	0	0	0	< 0.0001	> 99.9999

TABLE 2. (CONTINUED)

TEST #3 CHLORINE (MG/L): 5.2 KCL (MG/L): 526 CONTROL (PFU/ML): 128000
 INITIAL CHLORINE (MG/L): 5.3

TIME (MIN.)	SAMPLE 1 (PFU/ML)	SAMPLE 2 (PFU/ML)	AVERAGE (PFU/ML)	SURVIVAL (%)	INACTIVATION (%)
.25	1360	1800	1580	1.2343	98.7657
.5	196	224	210	.164	99.836
.75	40	20	30	.0234	99.9766
1	0	0	0	< 0.0001	> 99.9999
1.25	0	0	0	< 0.0001	> 99.9999
1.5	0	0	0	< 0.0001	> 99.9999
1.75	0	0	0	< 0.0001	> 99.9999
2	0	0	0	< 0.0001	> 99.9999
2.25	0	0	0	< 0.0001	> 99.9999
2.5	0	0	0	< 0.0001	> 99.9999

TEST #4 CHLORINE (MG/L): 5.15 KCL (MG/L): 1,262 CONTROL (PFU/ML): 128000
 INITIAL CHLORINE (MG/L): 5.3

TIME (MIN.)	SAMPLE 1 (PFU/ML)	SAMPLE 2 (PFU/ML)	AVERAGE (PFU/ML)	SURVIVAL (%)	INACTIVATION (%)
.25	160	176	168	.1312	99.8688
.5	16	16	16	.0125	99.9875
.75	4	4	4	3.1E-03	99.9969
1	0	4	2	1.5E-03	99.9985
1.25	0	0	0	< 0.0001	> 99.9999
1.5	0	0	0	< 0.0001	> 99.9999
1.75	0	0	0	< 0.0001	> 99.9999
2	0	0	0	< 0.0001	> 99.9999
2.25	0	0	0	< 0.0001	> 99.9999
2.5	0	0	0	< 0.0001	> 99.9999

TABLE 3. INACTIVATION OF POLIOVIRUS 1 AT 5°C IN BORATE-SUFFERED
PURIFIED WATER AT PH 9.0 BY APPROXIMATELY 1 MG/L
OF FREE CHLORINE IN THE PRESENCE AND ABSENCE OF KCL

TEST #1 CHLORINE (MG/L): 1.22 KCL (MG/L): 0 CONTROL (PFU/ML): 167500
INITIAL CHLORINE (MG/L): 1.3

TIME (MIN.)	SAMPLE 1 (PFU/ML)	SAMPLE 2 (PFU/ML)	AVERAGE (PFU/ML)	SURVIVAL (%)	INACTIVATION (%)
5	40000	56000	48000	28.6567	71.3433
10	2400	5200	3800	2.2686	97.7314
15	2400	2000	2200	1.3134	98.6866
20	24	44	34	.0292	99.9798
25	0	0	0	< 0.0001	> 99.9999
30	0	0	0	< 0.0001	> 99.9999
35	0	0	0	< 0.0001	> 99.9999
40	0	0	0	< 0.0001	> 99.9999
45	0	0	0	< 0.0001	> 99.9999
50	0	0	0	< 0.0001	> 99.9999

TEST #2 CHLORINE (MG/L): 1.16 KCL (MG/L): 21 CONTROL (PFU/ML): 167500
INITIAL CHLORINE (MG/L): 1.3

TIME (MIN.)	SAMPLE 1 (PFU/ML)	SAMPLE 2 (PFU/ML)	AVERAGE (PFU/ML)	SURVIVAL (%)	INACTIVATION (%)
4	64000	68000	66000	39.4029	60.5971
8	24000	28000	26000	15.5223	84.4777
12	6800	6400	5600	3.3432	96.6568
16	920	1040	980	.585	99.415
20	0	8	4	2.3E-03	99.9977
24	12	4	8	4.7E-03	99.9953
28	4	0	2	1.1E-03	99.9989
32	0	0	0	< 0.0001	> 99.9999
36	0	0	0	< 0.0001	> 99.9999
40	0	0	0	< 0.0001	> 99.9999

TABLE 3. (CONTINUED)

TEST #3 CHLORINE (MG/L): 1.14 KCL (MG/L): 526 CONTROL (PFU/ML): 167500
 INITIAL CHLORINE (MG/L): 1.3

TIME (MIN.)	SAMPLE 1 (PFU/ML)	SAMPLE 2 (PFU/ML)	AVERAGE (PFU/ML)	SURVIVAL (%)	INACTIVATION (%)
4	68000	64000	66000	39.4029	60.5971
8	2000	2480	2240	1.3373	98.6627
12	60	80	70	.0417	99.9583
16	28	20	24	.0143	99.9857
20	16	16	16	9.5E-03	99.9905
24	4	0	2	1.1E-03	99.9989
28	0	4	2	1.1E-03	99.9989
32	4	12	8	4.7E-03	99.9953
36	0	0	0	< 0.0001	> 99.9999
40	12	12	12	7.1E-03	99.9929

TEST #4 CHLORINE (MG/L): 1.2 KCL (MG/L): 1,262 CONTROL (PFU/ML): 167500
 INITIAL CHLORINE (MG/L): 1.3

TIME (MIN.)	SAMPLE 1 (PFU/ML)	SAMPLE 2 (PFU/ML)	AVERAGE (PFU/ML)	SURVIVAL (%)	INACTIVATION (%)
4	640	720	680	.4059	99.5941
8	80	40	60	.0358	99.9642
12	32	20	26	.0155	99.9843
16	0	16	8	4.7E-03	99.9953
20	0	8	4	2.3E-03	99.9977
24	0	0	0	< 0.0001	> 99.9999
28	0	0	0	< 0.0001	> 99.9999
32	0	0	0	< 0.0001	> 99.9999
36	0	0	0	< 0.0001	> 99.9999
40	0	0	0	< 0.0001	> 99.9999

TABLE 4. INACTIVATION OF POLIOVIRUS 1 AT 5°C IN BORATE-BUFFERED PURIFIED WATER AT PH 9.0 BY APPROXIMATELY 1 MG/L OF FREE CHLORINE IN THE PRESENCE AND ABSENCE OF KCL.

TEST #1 CHLORINE (MG/L): 1.08 KCL (MG/L): 0 CONTROL (PFU/ML): 117000
INITIAL CHLORINE (MG/L): 1.12

TIME (MIN.)	SAMPLE 1 (PFU/ML)	SAMPLE 2 (PFU/ML)	AVERAGE (PFU/ML)	SURVIVAL (%)	INACTIVATION (%)
2	52000	52000	52000	44.4444	55.5556
4	44000	104000	74000	63.2478	36.7522
6	21200	21200	21200	18.1196	81.8804
8	19200	20000	19600	16.7521	83.2479
10	9600	6400	8000	6.8376	93.1624
12	3200	7200	5200	4.4444	95.5556
14	1200	1440	1320	1.1282	98.8718
16	228	116	172	.147	99.853
18	108	76	92	.0786	99.9214
20	80	68	74	.0632	99.9368

TEST #2 CHLORINE (MG/L): 1.05 KCL (MG/L): 21 CONTROL (PFU/ML): 117000
INITIAL CHLORINE (MG/L): 1.12

TIME (MIN.)	SAMPLE 1 (PFU/ML)	SAMPLE 2 (PFU/ML)	AVERAGE (PFU/ML)	SURVIVAL (%)	INACTIVATION (%)
2	92000	100000	96000	82.0512001	17.9488
4	52000	48000	50000	42.733	57.265
6	16800	16800	16800	14.3589	85.6411
8	14400	16000	15200	12.9914	87.0086
10	11600	11600	11600	9.9145	90.0853
12	8000	6000	7000	5.9829	94.0171
14	2400	2080	2240	1.9143	98.0855
16	1000	720	860	.733	99.265
18	108	144	126	.1076	99.8924
20	12	12	12	.0102	99.9898

TABLE 4. (CONTINUED)

TEST #3 CHLORINE (MG/L): 1.04 KC1 (MG/L): 526 CONTROL (PFU/ML): 117000
 INITIAL CHLORINE (MG/L): 1.12

TIME (MIN.)	SAMPLE 1 (PFU/ML)	SAMPLE 2 (PFU/ML)	AVERAGE (PFU/ML)	SURVIVAL (%)	INACTIVATION (%)
2	116000	120000	118000	100.8547	>.854499999
4	140000	108000	124000	105.9829	-5.9829
6	72000	72000	72000	61.5384	38.4616
8	4800	4400	4600	3.9316	96.0684
10	9600	11200	10400	8.8888	91.1112
12	2400	2000	2200	1.8803	98.1197
14	1360	1040	1200	1.0256	98.9744
16	136	124	140	.1196	99.8804
18	20	20	20	.017	99.983
20	0	0	0	< 0.0001	> 99.9999

TEST #4 CHLURINE (MG/L): 1.01 KC1 (MG/L): 1,262 CONTROL (PFU/ML): 117000
 INITIAL CHLORINE (MG/L): 1.12

TIME (MIN.)	SAMPLE 1 (PFU/ML)	SAMPLE 2 (PFU/ML)	AVERAGE (PFU/ML)	SURVIVAL (%)	INACTIVATION (%)
1.5	60000	96000	78000	66.6666	33.3334
3	92000	84000	88000	73.2136001	24.7864
4.5	8000	20000	14000	11.9658	88.0342
6	13200	11600	12400	11.4529	88.5471
7.5	6400	1600	4000	3.4188	96.5812
9	600	920	760	.8495	99.3505
10.5	132	88	110	.094	99.906
12	8	16	12	.0102	99.9898
13.5	0	0	0	< 0.0001	> 99.9999
15	0	0	0	< 0.0001	> 99.9999

TABLE 5. INACTIVATION OF POLIOVIRUS 1 AT 5°C IN BORATE-BUFFERED
PURIFIED WATER AT PH 9.0 BY APPROXIMATELY 5 MG/L
OF FREE CHLORINE IN THE PRESENCE AND ABSENCE OF KCl

TEST #1 CHLORINE (MG/L): 5.05 KCl (MG/L): 0 CONTROL (PFU/ML): 111000
INITIAL CHLORINE (MG/L): 5.25

TIME (MIN.)	SAMPLE 1 (PFU/ML)	SAMPLE 2 (PFU/ML)	AVERAGE (PFU/ML)	SURVIVAL (%)	INACTIVATION (%)
.5	80000	56000	68000	61.2612	38.7388
1	20800	24000	22400	20.1801	79.8199
1.5	18400	14000	16200	14.5945	85.4055
2	14800	12400	13600	12.2522	87.7478
2.5	8400	10400	9400	8.4484	91.5316
3	8400	6400	7400	6.6666	93.3334
3.5	7600	6000	6800	6.1261	93.8739
4	1440	1160	1300	1.1711	98.8289
4.5	1040	960	1000	.9009	99.0991
5	1400	1160	1280	1.1531	98.8469

TEST #2 CHLORINE (MG/L): 5 KCl (MG/L): 21 CONTROL (PFU/ML): 111000
INITIAL CHLORINE (MG/L): 5.25

TIME (MIN.)	SAMPLE 1 (PFU/ML)	SAMPLE 2 (PFU/ML)	AVERAGE (PFU/ML)	SURVIVAL (%)	INACTIVATION (%)
.5	N/A	N/A	N/A	N/A	N/A
1	N/A	N/A	N/A	N/A	N/A
1.5	48000	48000	48000	43.2432	56.7568
2	17200	18800	18000	16.2162	83.7838
2.5	13200	12800	14000	12.6126	87.3874
3	7200	9200	8200	7.3873	92.6127
3.5	7200	7200	7200	6.4864	93.5136
4	4400	5600	5000	4.5045	95.4955
4.5	1560	1560	1560	1.4054	98.5946
5	880	840	860	.7747	99.2253

TABLE 5. (CONTINUED)

TEST #3 CHLORINE (MG/L): 5.05 KCl (MG/L): 526 CONTROL (PFU/ML): 111000
 INITIAL CHLORINE (MG/L): 5.25

TIME (MIN.)	SAMPLE 1 (PFU/ML)	SAMPLE 2 (PFU/ML)	AVERAGE (PFU/ML)	SURVIVAL (%)	INACTIVATION (%)
.5	16800	17600	17200	15.4954	84.5046
1	13600	12000	12800	11.5313	88.4685
1.5	1960	2400	2180	1.9639	98.0361
2	680	440	560	.5045	99.4955
2.5	80	64	72	.0644	99.9352
3	36	16	26	.0234	99.9766
3.5	4	4	4	3.6E-03	99.9964
4	8	24	16	.0144	99.9856
4.5	4	4	4	3.6E-03	99.9964
5	12	12	12	.0108	99.9892

TEST #4 CHLORINE (MG/L): 5 KCl (MG/L): 1,262 CONTROL (PFU/ML): 111000
 INITIAL CHLORINE (MG/L): 5.25

TIME (MIN.)	SAMPLE 1 (PFU/ML)	SAMPLE 2 (PFU/ML)	AVERAGE (PFU/ML)	SURVIVAL (%)	INACTIVATION (%)
.5	19200	24400	21800	19.6396	80.3604
1	1520	1360	1440	1.2972	98.7028
1.25	800	520	660	.5945	99.4055
1.5	116	88	102	.0918	99.9082
1.75	36	8	22	.0198	99.9802
2	32	36	34	.0306	99.9694
2.25	4	16	10	9E-03	99.991
2.5	8	12	10	9E-03	99.991
2.75	8	4	6	5.4E-03	99.9946
3	0	0	0	< 0.0001	> 99.9999

TABLE 6. INACTIVATION OF POLIOVIRUS 1 AT 5°C IN BORATE-BUFFERED
TAP WATER AT PH 9.0 BY APPROXIMATELY 5 MG/L OF FREE CHLORINE
IN THE PRESENCE AND ABSENCE OF KCl

TEST #1 CHLORINE (MG/L): 5.2 KCl (MG/L): 0 CONTROL (PFU/ML): 60000
INITIAL CHLORINE (MG/L): 5.3

TIME (MIN.)	SAMPLE 1 (PFU/ML)	SAMPLE 2 (PFU/ML)	AVERAGE (PFU/ML)	SURVIVAL (%)	INACTIVATION (%)
1	4400	3200	3800	6.3333	93.6667
2	40	200	120	.2	99.8
3	16	24	20	.0333	99.9667
4	4	0	2	3.3E-03	99.9967
5	0	4	2	3.3E-03	99.9967
6	0	0	0	< 0.0001	> 99.9999
7	0	0	0	< 0.0001	> 99.9999
8	0	0	0	< 0.0001	> 99.9999
9	0	0	0	< 0.0001	> 99.9999
10	0	0	0	< 0.0001	> 99.9999

TEST #2 CHLORINE (MG/L): 5.17 KCl (MG/L): 21 CONTROL (PFU/ML): 60000
INITIAL CHLORINE (MG/L): 5.3

TIME (MIN.)	SAMPLE 1 (PFU/ML)	SAMPLE 2 (PFU/ML)	AVERAGE (PFU/ML)	SURVIVAL (%)	INACTIVATION (%)
1	4400	6800	5600	9.3333	90.6667
2	144	184	164	.2733	99.7267
3	32	20	26	.0433	99.9567
4	0	4	2	3.3E-03	99.9967
5	0	0	0	< 0.0001	> 99.9999
6	0	0	0	< 0.0001	> 99.9999
7	0	0	0	< 0.0001	> 99.9999
8	0	0	0	< 0.0001	> 99.9999
9	0	0	0	< 0.0001	> 99.9999
10	0	0	0	< 0.0001	> 99.9999

TABLE 6. (CONTINUED)

TEST #3 CHLORINE (MG/L): 5.1 KCl (MG/L): 526 CONTROL (PFU/ML): 60000
 INITIAL CHLORINE (MG/L): 5.3

TIME (MIN.)	SAMPLE 1 (PFU/ML)	SAMPLE 2 (PFU/ML)	AVERAGE (PFU/ML)	SURVIVAL (%)	INACTIVATION (%)
.5	3440	3200	3320	5.5333	94.4667
1	160	160	160	.2666	99.7334
1.5	64	64	64	.1066	99.8934
2	20	32	26	.0433	99.9567
2.5	16	8	12	.0199	99.9801
3	12	12	12	.0199	99.9801
3.5	8	12	10	.0166	99.9834
4	0	0	0	< 0.0001	> 99.9999
4.5	0	0	0	< 0.0001	> 99.9999
5	0	0	0	< 0.0001	> 99.9999

TEST #4 CHLORINE (MG/L): 5 KCl (MG/L): 1,262 CONTROL (PFU/ML): 60000
 INITIAL CHLORINE (MG/L): 5.3

TIME (MIN.)	SAMPLE 1 (PFU/ML)	SAMPLE 2 (PFU/ML)	AVERAGE (PFU/ML)	SURVIVAL (%)	INACTIVATION (%)
.5	680	680	680	1.1333	98.8667
1	72	88	80	.1333	99.8667
1.25	48	52	50	.0833	99.9167
1.5	56	52	54	.0899	99.9101
1.75	32	16	24	.0399	99.9601
2	32	20	26	.0433	99.9567
2.25	12	16	14	.0233	99.9767
2.5	0	8	4	6.67E-03	99.9934
2.75	12	8	10	.0166	99.9834
3	4	12	8	.0133	99.9867

TABLE 7. INACTIVATION OF POLIOVIRUS 1 AT 5°C IN NONBUFFERED
PURIFIED WATER AT PH 9.0 BY APPROXIMATELY 1 MG/L OF
FREE CHLORINE IN THE PRESENCE & ABSENCE OF KC1.

TEST #1 CHLORINE (MG/L): .95 KC1 (MG/L): 0 CONTROL (PFU/ML): 145000
INITIAL CHLORINE (MG/L): 1.03

TIME (MIN.)	SAMPLE 1 (PFU/ML)	SAMPLE 2 (PFU/ML)	AVERAGE (PFU/ML)	SURVIVAL (%)	INACTIVATION (%)
4	88000	144000	116000	80	20
6.5	88000	88000	88000	60.6896	39.3104
12	68000	72000	70000	48.2758	51.7242
16	64000	28000	46000	31.7241	68.2759
20	15600	17200	16400	11.3103	88.6897
24	15600	18400	17000	11.7241	88.2759
28	16800	16400	16600	11.4482	88.5518
32	8800	9200	9000	6.2068	93.7932
36	4400	4000	4200	2.8965	97.1035
40	4400	3600	4000	2.7586	97.2414
44	4800	6000	5400	3.7241	96.2759
48	2000	1840	1920	1.3241	98.6759

TEST #2 CHLORINE (MG/L): .93 KC1 (MG/L): 21 CONTROL (PFU/ML): 145000
INITIAL CHLORINE (MG/L): 1.03

TIME (MIN.)	SAMPLE 1 (PFU/ML)	SAMPLE 2 (PFU/ML)	AVERAGE (PFU/ML)	SURVIVAL (%)	INACTIVATION (%)
4	120000	124000	122000	84.1379	15.8621
8	40000	40000	40000	27.5862	72.4138
12	44000	44000	44000	30.3448	69.6552
16	15200	14400	14800	10.2068	89.7932
20	14400	16400	15400	10.6206	89.3794
24	7600	10800	9200	6.3448	93.6552
28	4000	4000	4000	2.7586	97.2414
32	1600	1880	1740	1.2	98.8
36	1080	800	940	.6482	99.3518
40	760	480	620	.4275	99.3725
44	360	360	360	.2482	99.7518
48	68	60	64	.0441	99.9559

TABLE 7. (CONTINUED)

TEST #3 CHLORINE (MG/L): .9 KCl (MG/L): 526 CONTROL (PFU/ML): 145000
 INITIAL CHLORINE (MG/L): 1.03

TIME (MIN.)	SAMPLE 1 (PFU/ML)	SAMPLE 2 (PFU/ML)	AVERAGE (PFU/ML)	SURVIVAL (%)	INACTIVATION (%)
2	108000	132000	120000	82.7586	17.2414
4	48000	52000	50000	34.4827	65.5173
6	68000	28000	48000	33.1034	66.8966
8	12800	10800	11800	8.1379	91.8621
10	3200	3600	3400	2.3448	97.6552
12	720	520	620	.4275	99.5725
14	96	84	90	.062	99.938
16	12	16	14	9.6E-03	99.9904
18	8	0	4	2.7E-03	99.9973
20	4	4	4	2.7E-03	99.9973
22	N/A	N/A	N/A	N/A	N/A
24	N/A	N/A	N/A	N/A	N/A

TEST #4 CHLORINE (MG/L): .85 KCl (MG/L): 1,262 CONTROL (PFU/ML): 145000
 INITIAL CHLORINE (MG/L): 1.03

TIME (MIN.)	SAMPLE 1 (PFU/ML)	SAMPLE 2 (PFU/ML)	AVERAGE (PFU/ML)	SURVIVAL (%)	INACTIVATION (%)
1	76000	40000	58000	40	60
2	1840	2000	1920	1.3241	98.6759
3	120	112	116	.0799	99.9201
4	28	36	32	.022	99.978
5	16	4	10	6.8E-03	99.9932
6	0	0	0	< 0.0001	> 99.9999
7	0	0	0	< 0.0001	> 99.9999
8	4	8	6	4.1E-03	99.9959
9	8	0	4	2.7E-03	99.9973
10	N/A	N/A	N/A	N/A	N/A
11	0	0	0	< 0.0001	> 99.9999
12	0	0	0	< 0.0001	> 99.9999

TABLE 8. INACTIVATION OF POLIOVIRUS 1 AT 5°C IN NONBUFFERED
PURIFIED WATER AT PH 9.0 BY APPROXIMATELY 5 MG/L OF
FREE CHLORINE IN THE PRESENCE & ABSENCE OF KCl.

TEST #1 CHLORINE (MG/L): 5 KCl (MG/L): 0 CONTROL (PFU/ML): 110000
INITIAL CHLORINE (MG/L): 5.13

TIME (MIN.)	SAMPLE 1 (PFU/ML)	SAMPLE 2 (PFU/ML)	AVERAGE (PFU/ML)	SURVIVAL (%)	INACTIVATION (%)
2	64000	32000	48000	43.6363	56.3637
4	14800	8000	11400	10.3636	89.6364
6	11200	10400	10800	9.8181	90.1819
8	6400	4800	5600	5.0909	94.9091
10	1960	1600	1780	1.6181	98.3819
12	1480	1400	1440	1.309	98.691
14	480	640	560	.509	99.491
16	156	124	140	.1272	99.8728
18	68	88	78	.0709	99.9291
20	N/A	N/A	N/A	N/A	N/A

TEST #2 CHLORINE (MG/L): 5 KCl (MG/L): 21 CONTROL (PFU/ML): 110000
INITIAL CHLORINE (MG/L): 5.13

TIME (MIN.)	SAMPLE 1 (PFU/ML)	SAMPLE 2 (PFU/ML)	AVERAGE (PFU/ML)	SURVIVAL (%)	INACTIVATION (%)
2	52000	32000	42000	38.1818	61.8182
4	15600	15200	15400	14	86
6	10800	12400	11600	10.5454	89.4546
8	6800	5200	6000	3.45450001	94.5455
10	1600	1800	1700	1.5454	98.4546
12	800	1040	920	.8363	99.1637
14	196	208	202	.1836	99.8164
16	84	84	84	.0763	99.9237
18	8	40	24	.0218	99.9782
20	12	16	14	.0127	99.9873

TABLE 8. (CONTINUED)

TEST #3 CHLORINE (MG/L): 4.88 KCl (MG/L): 526 CONTROL (PFU/ML): 110000
 INITIAL CHLORINE (MG/L): 5.13

TIME (MIN.)	SAMPLE 1 (PFU/ML)	SAMPLE 2 (PFU/ML)	AVERAGE (PFU/ML)	SURVIVAL (%)	INACTIVATION (%)
.5	40000	44000	42000	38.1818	61.8182
.75	12400	10400	11400	10.3636	89.6364
1	10800	9600	10200	9.2727	90.7273
1.25	7600	10400	9000	8.1818	91.8182
1.5	4400	3600	5000	4.5454	95.4546
1.75	1720	1600	1660	1.509	98.491
2	1560	1400	1480	1.3454	98.6346
2.25	680	1040	860	.7818	99.2182
2.5	440	440	440	.4	99.6
3	520	440	480	.4363	99.5637

TEST #4 CHLORINE (MG/L): 4.83 KCl (MG/L): 1,262 CONTROL (PFU/ML): 110000
 INITIAL CHLORINE (MG/L): 5.13

TIME (MIN.)	SAMPLE 1 (PFU/ML)	SAMPLE 2 (PFU/ML)	AVERAGE (PFU/ML)	SURVIVAL (%)	INACTIVATION (%)
.25	19600	20000	19800	18	82
.5	12000	8800	10400	9.4545	90.5455
.75	8000	4000	6000	3.45450001	94.5455
1	1840	1720	1780	1.6181	98.3819
1.25	840	680	760	.6909	99.3091
1.5	440	600	520	.4727	99.5273
1.75	252	240	246	.2236	99.7764
2	96	84	90	.0818	99.9182
2.25	40	44	42	.0381	99.9619
2.5	24	36	30	.0272	99.9728

TABLE 9. INACTIVATION OF POLIOVIRUS 1 AT 5°C IN NONBUFFERED PURIFIED WATER AT PH 9.0 BY APPROXIMATELY 5 MG/L FREE CHLORINE IN THE PRESENCE & ABSENCE OF KCl.

TEST #1 CHLORINE (MG/L): 5 KCl (MG/L): 0 CONTROL (PFU/ML): 110000
INITIAL CHLORINE (MG/L): 5.05

TIME (MIN.)	SAMPLE 1 (PFU/ML)	SAMPLE 2 (PFU/ML)	AVERAGE (PFU/ML)	SURVIVAL (%)	INACTIVATION (%)
1	24000	48000	36000	32.7272	67.2728
2	18400	16800	17600	16	84
3	16000	32000	24000	21.8181	78.1819
4	8800	12000	10400	9.4343	90.5455
5	11600	9200	10400	9.4343	90.5455
6	5600	7600	6600	6	94
7	6000	7200	6600	6	94
8	4000	4800	4400	4	96
9	2800	2560	2680	2.4363	97.5637
10	6800	6800	6800	6.1818	93.8182
12	1640	1640	1640	1.4909	98.5091
14	1400	1320	1460	1.3272	98.6728

TEST #2 CHLORINE (MG/L): 5.05 KCl (MG/L): 21 CONTROL (PFU/ML): 110000
INITIAL CHLORINE (MG/L): 5.05

TIME (MIN.)	SAMPLE 1 (PFU/ML)	SAMPLE 2 (PFU/ML)	AVERAGE (PFU/ML)	SURVIVAL (%)	INACTIVATION (%)
1	40000	80000	60000	54.5454	45.4546
2	44000	36000	40000	36.3636	63.6364
3	15200	16400	15800	14.3636	85.6364
4	10800	11600	11200	10.1818	89.8182
5	9600	9600	9600	8.72720001	91.2728
6	7600	8000	7800	7.0909	92.9091
7	12000	11600	11800	10.7272	89.2728
8	8400	9200	8800	8	92
9	6000	4400	5200	4.7272	95.2728
10	2560	2440	2500	2.2727	97.7273
12	1320	320	820	.7454	99.2546
14	268	232	250	.2272	99.7728

TABLE 9. (CONTINUED)

TEST #3 CHLORINE (MG/L): 4.95 KC1 (MG/L): 526 CONTROL (PFU/ML): 110000
 INITIAL CHLORINE (MG/L): 5.05

TIME (MIN.)	SAMPLE 1 (PFU/ML)	SAMPLE 2 (PFU/ML)	AVERAGE (PFU/ML)	SURVIVAL (%)	INACTIVATION (%)
.5	17200	7600	12400	11.2727	88.7273
1	5300	3600	5200	4.7272	95.2728
1.5	1200	1200	1200	1.0909	98.9091
2	196	208	202	.1836	99.8164
2.5	24	36	30	.0272	99.9728
3	24	16	20	.0181	99.9819
3.5	12	12	12	.0109	99.9891
4	28	28	28	.0254	99.9746
4.5	8	8	8	7.2E-03	99.9928
5	12	8	10	9E-03	99.991
5.5	N/A	N/A	N/A	N/A	N/A
6	N/A	N/A	N/A	N/A	N/A

TEST #4 CHLORINE (MG/L): 5 KC1 (MG/L): 1,262 CONTROL (PFU/ML): 110000
 INITIAL CHLORINE (MG/L): 5.05

TIME (MIN.)	SAMPLE 1 (PFU/ML)	SAMPLE 2 (PFU/ML)	AVERAGE (PFU/ML)	SURVIVAL (%)	INACTIVATION (%)
.5	N/A	N/A	N/A	N/A	N/A
.75	N/A	N/A	N/A	N/A	N/A
1	600	560	580	.5272	99.4728
1.25	N/A	N/A	N/A	N/A	N/A
1.5	72	32	52	.0472	99.9528
1.75	N/A	N/A	N/A	N/A	N/A
2	16	20	18	.0163	99.9837
2.25	N/A	N/A	N/A	N/A	N/A
2.5	0	0	0	< 0.0001	> 99.9999
2.75	N/A	N/A	N/A	N/A	N/A
3	0	0	0	< 0.0001	> 99.9999
3.25	N/A	N/A	N/A	N/A	N/A

TABLE 10. INACTIVATION OF POLIOVIRUS 1 AT 5°C IN NONBUFFERED TAP
WATER AT PH 9.0 BY APPROXIMATELY 1 MG/L OF FREE CHLORINE IN
THE PRESENCE AND ABSENCE OF KCl.

TEST #1 CHLORINE (MG/L): .95 KCl (MG/L): 0 CONTROL (PFU/ML): 132000
INITIAL CHLORINE (MG/L): 1.2

TIME (MIN.)	SAMPLE 1 (PFU/ML)	SAMPLE 2 (PFU/ML)	AVERAGE (PFU/ML)	SURVIVAL (%)	INACTIVATION (%)
6	1640	1840	1740	1.3181	98.6819
12	8	8	8	6E-03	99.994
18	4	8	6	4.5E-03	99.9955
24	0	0	0	< 0.0001	> 99.9999
30	4	0	2	1.5E-03	99.9985
36	0	0	0	< 0.0001	> 99.9999
42	0	0	0	< 0.0001	> 99.9999
48	0	0	0	< 0.0001	> 99.9999
54	0	0	0	< 0.0001	> 99.9999
60	0	0	0	< 0.0001	> 99.9999

TEST #2 CHLORINE (MG/L): 1.02 KCl (MG/L): 21 CONTROL (PFU/ML): 132000
INITIAL CHLORINE (MG/L): 1.2

TIME (MIN.)	SAMPLE 1 (PFU/ML)	SAMPLE 2 (PFU/ML)	AVERAGE (PFU/ML)	SURVIVAL (%)	INACTIVATION (%)
6	6400	5600	6000	4.5454	95.4546
12	68	88	78	.059	99.941
18	32	20	26	.0196	99.9804
24	4	16	10	7.5E-03	99.9925
30	4	0	2	1.5E-03	99.9985
36	0	0	0	< 0.0001	> 99.9999
42	0	0	0	< 0.0001	> 99.9999
48	0	0	0	< 0.0001	> 99.9999
54	0	0	0	< 0.0001	> 99.9999
60	0	0	0	< 0.0001	> 99.9999

TABLE 10. (CONTINUED)

TEST #3 CHLORINE (MG/L): 1 KCl (MG/L): 526 CONTROL (PFU/ML): 132000
 INITIAL CHLORINE (MG/L): 1.2

TIME (MIN.)	SAMPLE 1 (PFU/ML)	SAMPLE 2 (PFU/ML)	AVERAGE (PFU/ML)	SURVIVAL (%)	INACTIVATION (%)
2	1720	1400	1560	1.1818	98.8182
4	1760	1520	1640	1.2424	98.7576
6	196	164	180	.1363	99.8637
8	84	68	76	.0575	99.9425
10	16	12	14	.0106	99.9894
12	80	64	72	.0545	99.9455
14	36	12	24	.0181	99.9819
16	0	0	0	< 0.0001	> 99.9959
18	8	24	16	.0121	99.9879
20	0	4	2	1.5E-03	99.9985

TEST #4 CHLORINE (MG/L): 1.02 KCl (MG/L): 1,262 CONTROL (PFU/ML): 132000
 INITIAL CHLORINE (MG/L): 1.2

TIME (MIN.)	SAMPLE 1 (PFU/ML)	SAMPLE 2 (PFU/ML)	AVERAGE (PFU/ML)	SURVIVAL (%)	INACTIVATION (%)
.5	12400	6400	9400	7.1212	92.8788
1	2600	2800	2700	2.0454	97.9546
1.5	4000	4000	4000	3.0303	96.9697
2	680	640	660	.5	99.5
2.5	192	164	178	.1348	99.8652
3	152	164	158	.1196	99.8804
3.5	760	640	700	.5303	99.4497
4	92	108	100	.0757	99.9243
4.5	36	40	38	.0287	99.9713
5	104	96	100	.0757	99.9243

TABLE 11. INACTIVATION OF POLIOVIRUS 1 AT 5°C IN NONBUFFERED TAP WATER AT PH 9.0 BY APPROXIMATELY 5 MG/L OF FREE CHLORINE IN THE PRESENCE AND ABSENCE OF KCl.

TEST #1 CHLORINE (MG/L): 4.98 KCL (MG/L): 0 CONTROL (PFU/ML): 175000
INITIAL CHLORINE (MG/L): 5.05

TIME (MIN.)	SAMPLE 1 (PFU/ML)	SAMPLE 2 (PFU/ML)	AVERAGE (PFU/ML)	SURVIVAL (%)	INACTIVATION (%)
2	N/A	N/A	N/A	N/A	N/A
4	N/A	N/A	N/A	N/A	N/A
6	N/A	N/A	N/A	N/A	N/A
8	N/A	N/A	N/A	N/A	N/A
10	N/A	N/A	N/A	N/A	N/A
12	N/A	N/A	N/A	N/A	N/A
14	N/A	N/A	N/A	N/A	N/A
16	N/A	N/A	N/A	N/A	N/A
18	N/A	N/A	N/A	N/A	N/A
20	N/A	N/A	N/A	N/A	N/A

TEST #2 CHLORINE (MG/L): 5 KCl (MG/L): 0 CONTROL (PFU/ML): 175000
INITIAL CHLORINE (MG/L): 5.05

TIME (MIN.)	SAMPLE 1 (PFU/ML)	SAMPLE 2 (PFU/ML)	AVERAGE (PFU/ML)	SURVIVAL (%)	INACTIVATION (%)
1.5	1200	1040	1120	.6399	99.3601
3	18	8	12	6.8E-03	99.9932
4.5	6	4	4	2.2E-03	99.9978
6	0	0	0	< 0.0001	> 99.9999
7.5	0	0	0	< 0.0001	> 99.9999
9	0	0	0	< 0.0001	> 99.9999
11	0	0	0	< 0.0001	> 99.9999
13	0	0	0	< 0.0001	> 99.9999
15	0	0	0	< 0.0001	> 99.9999
17	0	0	0	< 0.0001	> 99.9999

TABLE 11. (CONTINUED)

TEST #3 CHLORINE (MG/L): 4.85 KC1 (MG/L): 526 CONTROL (PFU/ML): 175000
 INITIAL CHLORINE (MG/L): 5.05

TIME (MIN.)	SAMPLE 1 (PFU/ML)	SAMPLE 2 (PFU/ML)	AVERAGE (PFU/ML)	SURVIVAL (%)	INACTIVATION (%)
.5	18800	22800	20800	11.8857	88.1143
1	2240	1800	2020	1.1542	98.8458
1.5	220	236	228	.1302	99.8698
2	20	16	18	.0102	99.9898
2.5	8	20	14	.8E-03	99.9992
3	0	0	0	< 0.0001	> 99.9999
3.5	4	0	2	1.1E-03	99.9989
4	0	0	0	< 0.0001	> 99.9999
4.5	0	0	0	< 0.0001	> 99.9999
5	0	0	0	< 0.0001	> 99.9999

TEST #4 CHLORINE (MG/L): 4.8 KC1 (MG/L): 1,262 CONTROL (PFU/ML): 175000
 INITIAL CHLORINE (MG/L): 5.05

TIME (MIN.)	SAMPLE 1 (PFU/ML)	SAMPLE 2 (PFU/ML)	AVERAGE (PFU/ML)	SURVIVAL (%)	INACTIVATION (%)
.25	84000	92000	88000	50.2857	49.7143
.5	15200	19200	17200	9.8285	90.1715
.75	6000	8800	7400	4.2285	95.7715
1	2120	1960	2040	1.1657	98.8343
1.25	208	248	228	.1302	99.8698
1.5	40	40	40	.0228	99.9772
1.75	4	4	4	2.2E-03	99.9978
2	0	0	0	< 0.0001	> 99.9999
2.25	4	4	4	2.2E-03	99.9978
2.5	0	0	0	< 0.0001	> 99.9999

APPENDIX B
(LIST OF FIGURES [pH 4.5 and 9.0])

FIGURE 1. INACTIVATION OF POLIOVIRUS 1 AT 50°C IN PHthalate-BUFFERED
PURIFIED WATER AT pH 4.5 BY APPROXIMATELY 1 MG/L
OF FREE CHLORINE IN THE PRESENCE AND ABSENCE OF KCl

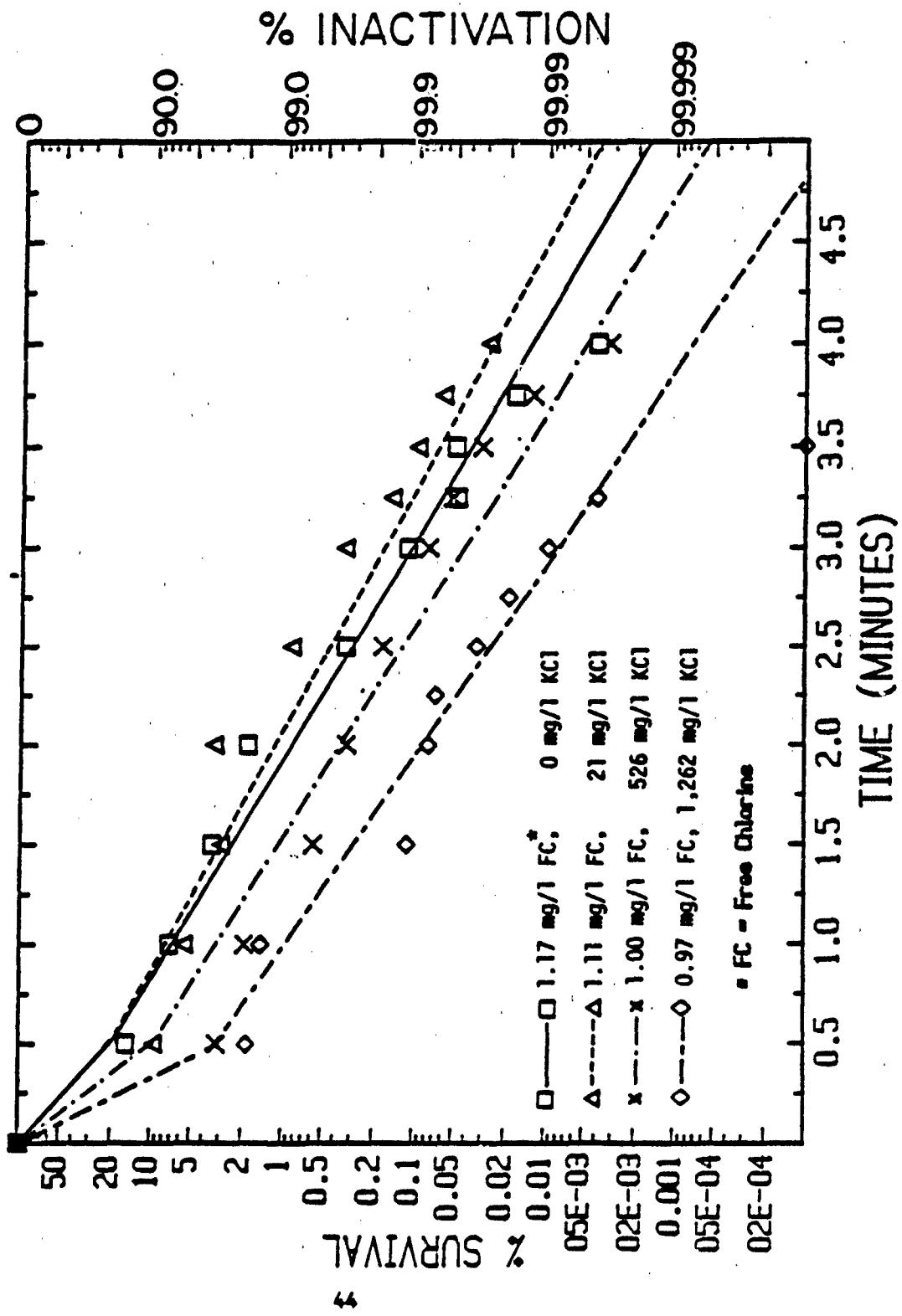


FIGURE 2. INACTIVATION OF POLIOVIRUS 1 AT 50°C IN PHthalate-BUFFERED PURIFIED WATER AT PH 4.5 BY APPROXIMATELY 5 MG/L OF FREE CHLORINE IN THE PRESENCE AND ABSENCE OF KCL

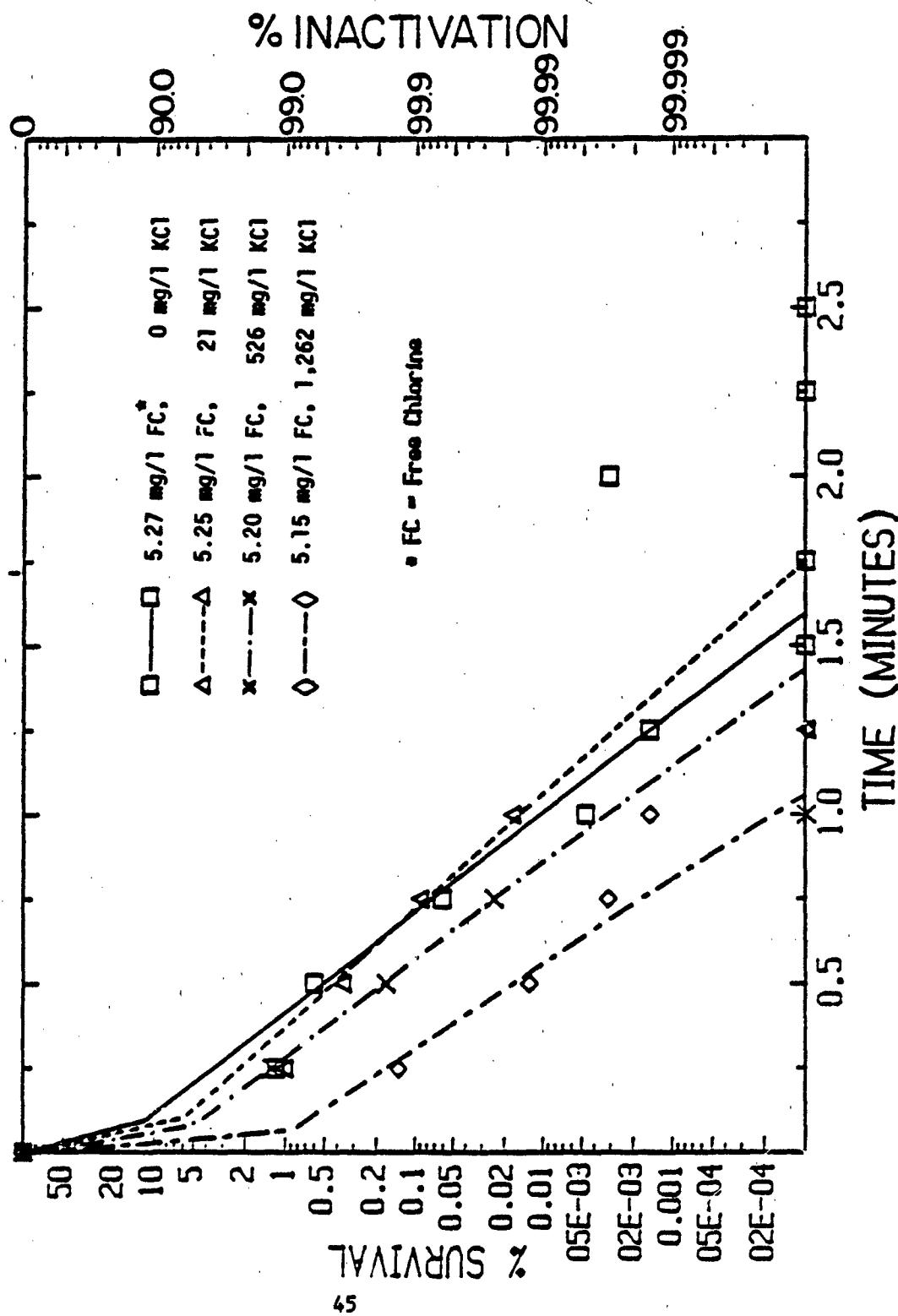


FIGURE 3. INACTIVATION OF POLIOVIRUS 1 AT 50°C IN BORATE-BUFFERED PURIFIED WATER AT pH 9.0 BY APPROXIMATELY 1 MG/L OF FREE CHLORINE IN THE PRESENCE AND ABSENCE OF KCL

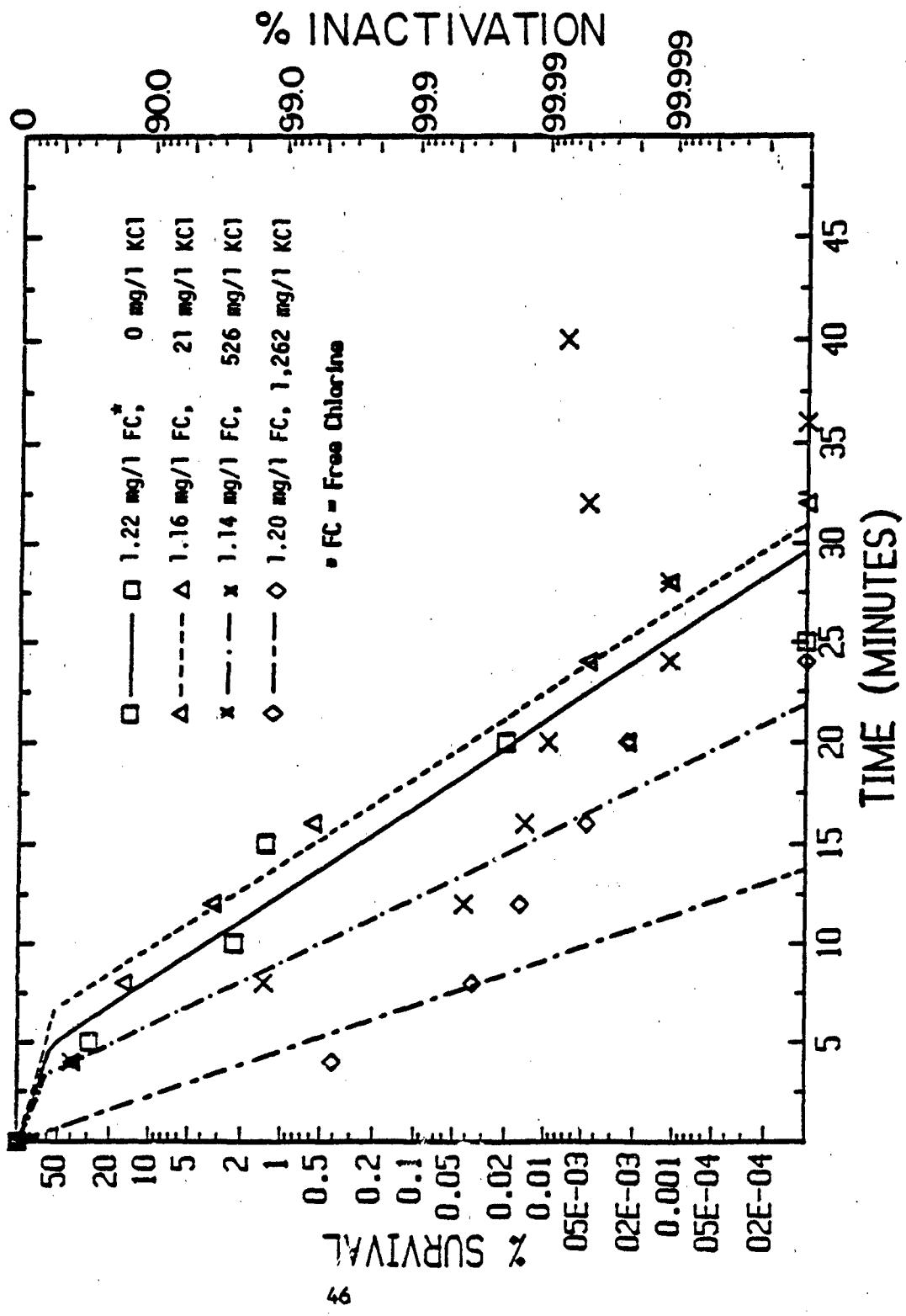


FIGURE 4. INACTIVATION OF POLIOVIRUS 1 AT 50°C IN BORATE-BUFFERED PURIFIED WATER AT pH 9.0 BY APPROXIMATELY 1 MG/L OF FREE CHLORINE IN THE PRESENCE AND ABSENCE OF KCL

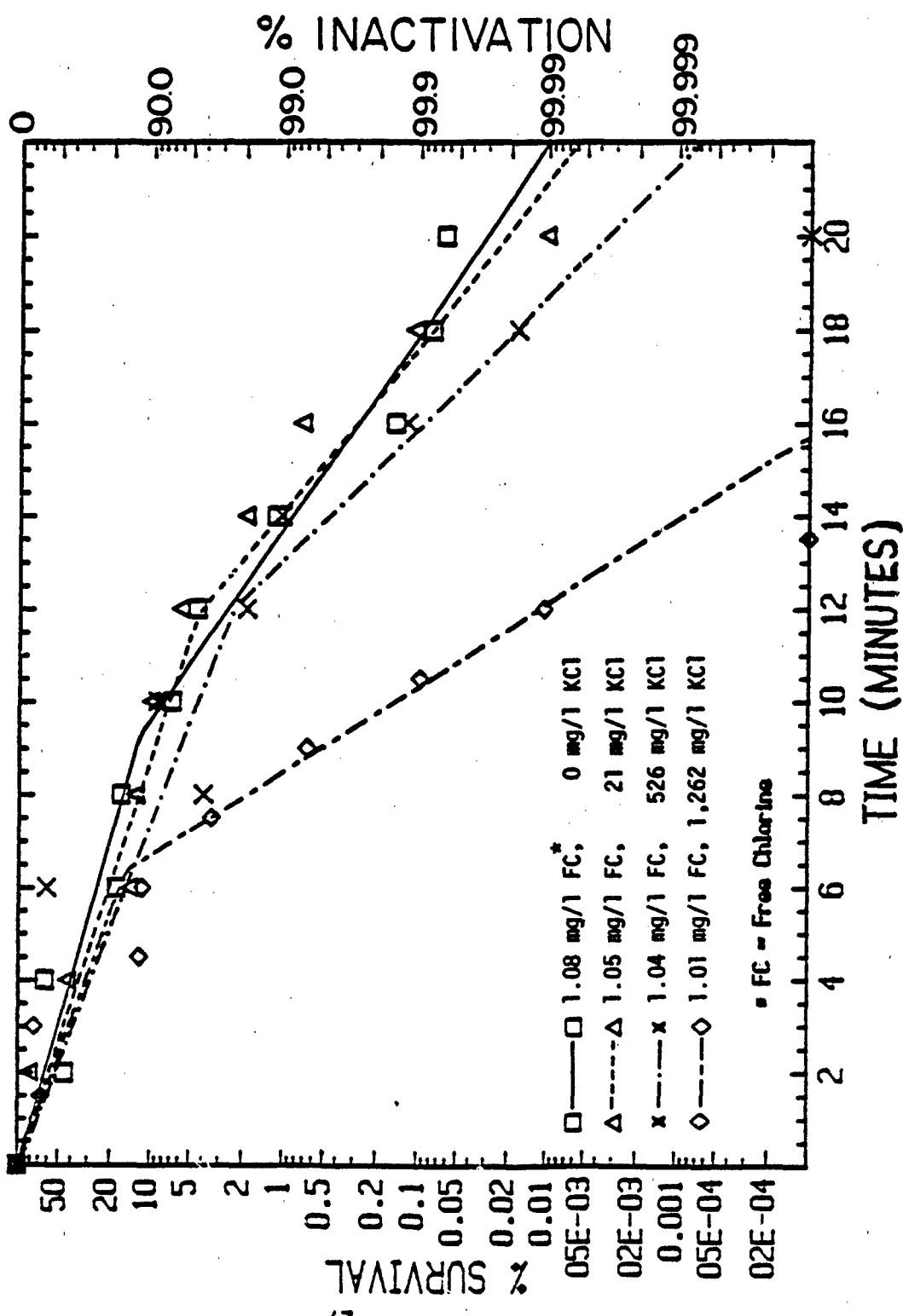


FIGURE 5. INACTIVATION OF POLIOVIRUS 1 AT 5°C IN BORATE-BUFFERED PURIFIED WATER AT pH 9.0 BY APPROXIMATELY 5 MG/L OF FREE CHLORINE IN THE PRESENCE AND ABSENCE OF KCL

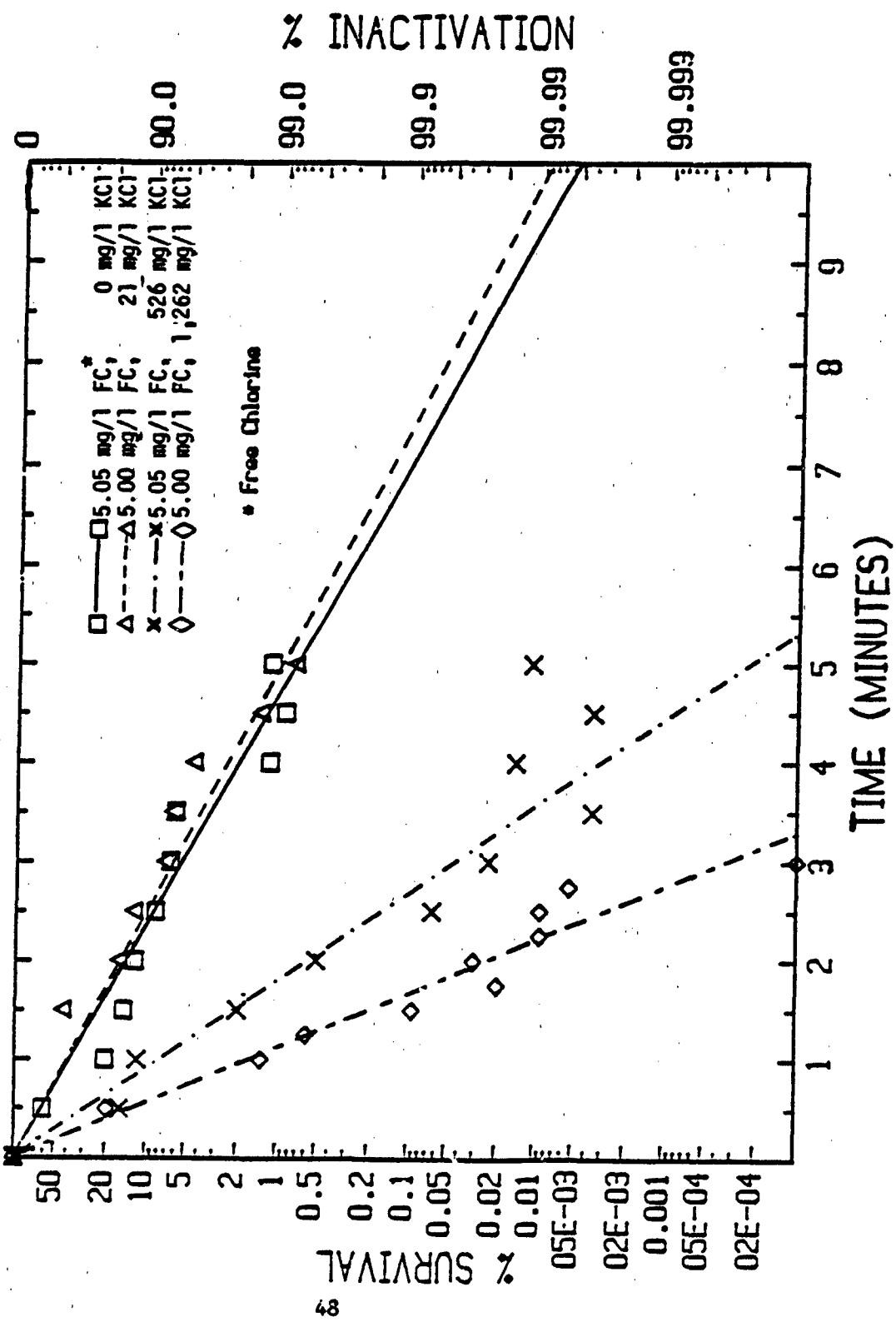


FIGURE 6. INACTIVATION OF POLIOVIRUS 1 AT 50°C IN BORATE-BUFFERED TAP WATER AT pH 9.0 BY APPROXIMATELY 5 MG/L OF FREE CHLORINE IN THE PRESENCE AND ABSENCE OF KCL

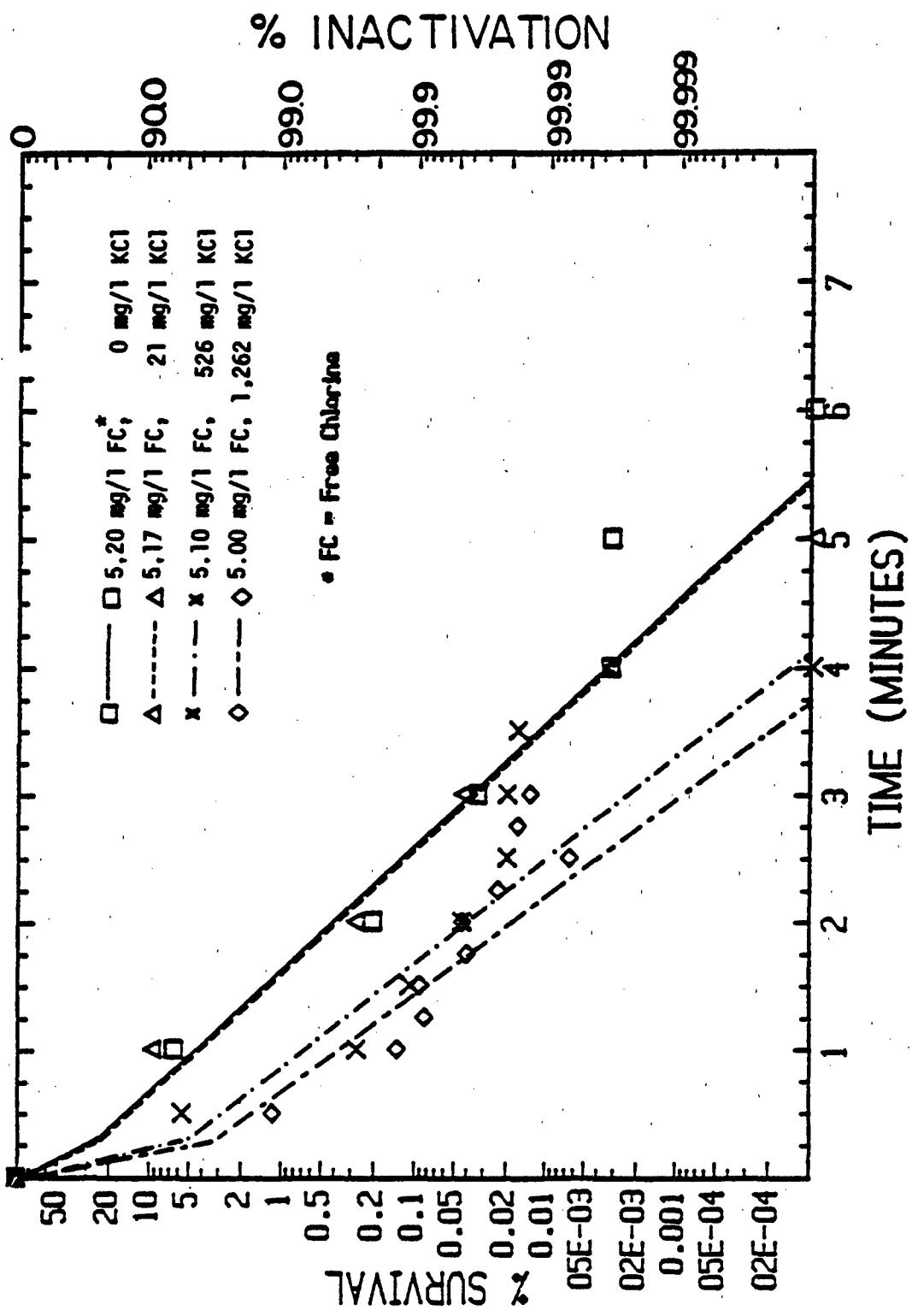


FIGURE 7. INACTIVATION OF POLIOVIRUS 1 AT 50°C IN NONBUFFERED PURIFIED WATER AT PH 9.0 BY APPROXIMATELY 1 MG/L OF FREE CHLORINE IN THE PRESENCE & ABSENCE OF KCL

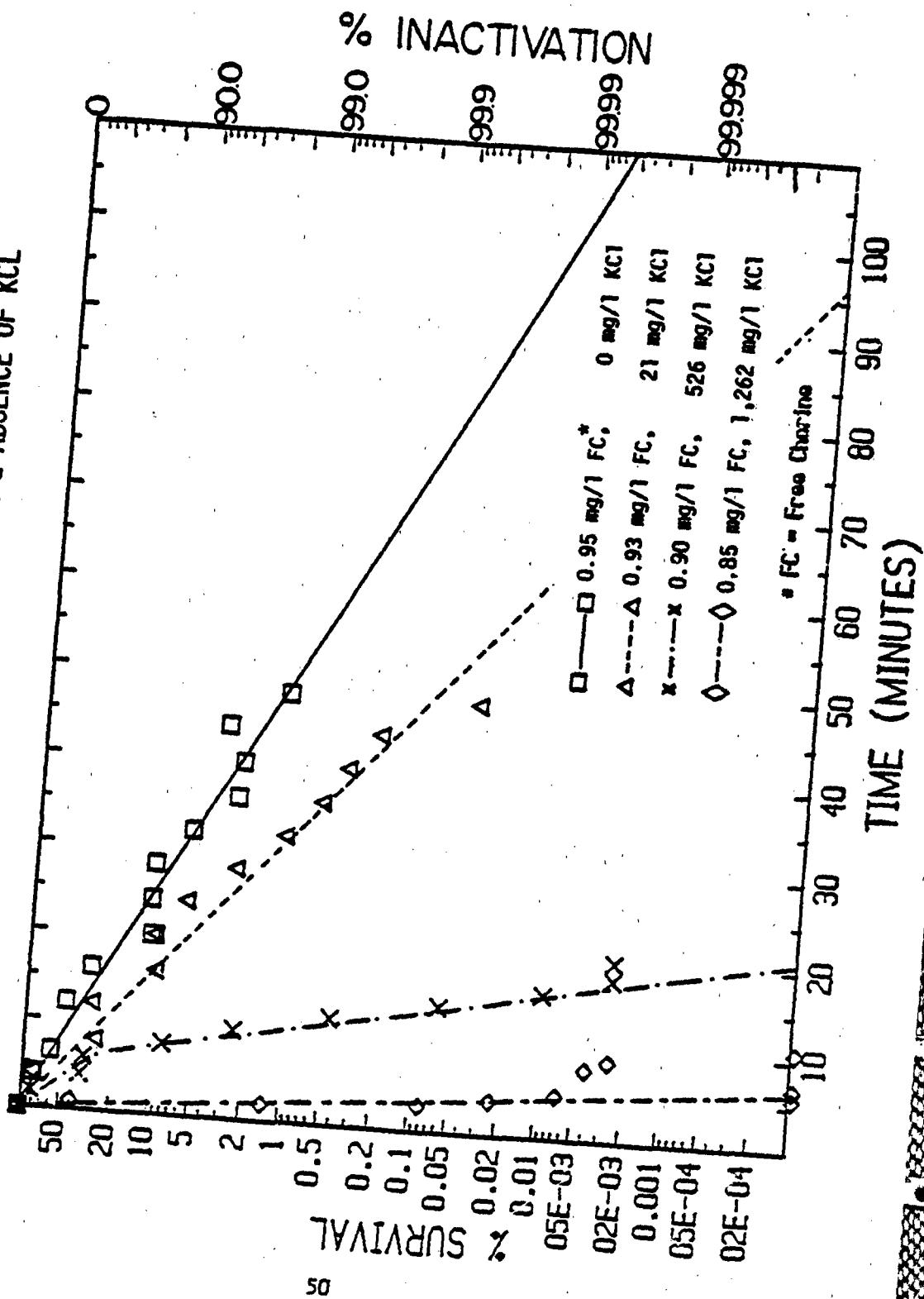


FIGURE 8. INACTIVATION OF POLIOVIRUS 1 AT 5°C IN NONBUFFERED PURIFIED WATER AT pH 9.0 BY APPROXIMATELY 5 MG/L OF FREE CHLORINE IN THE PRESENCE & ABSENCE OF KCL

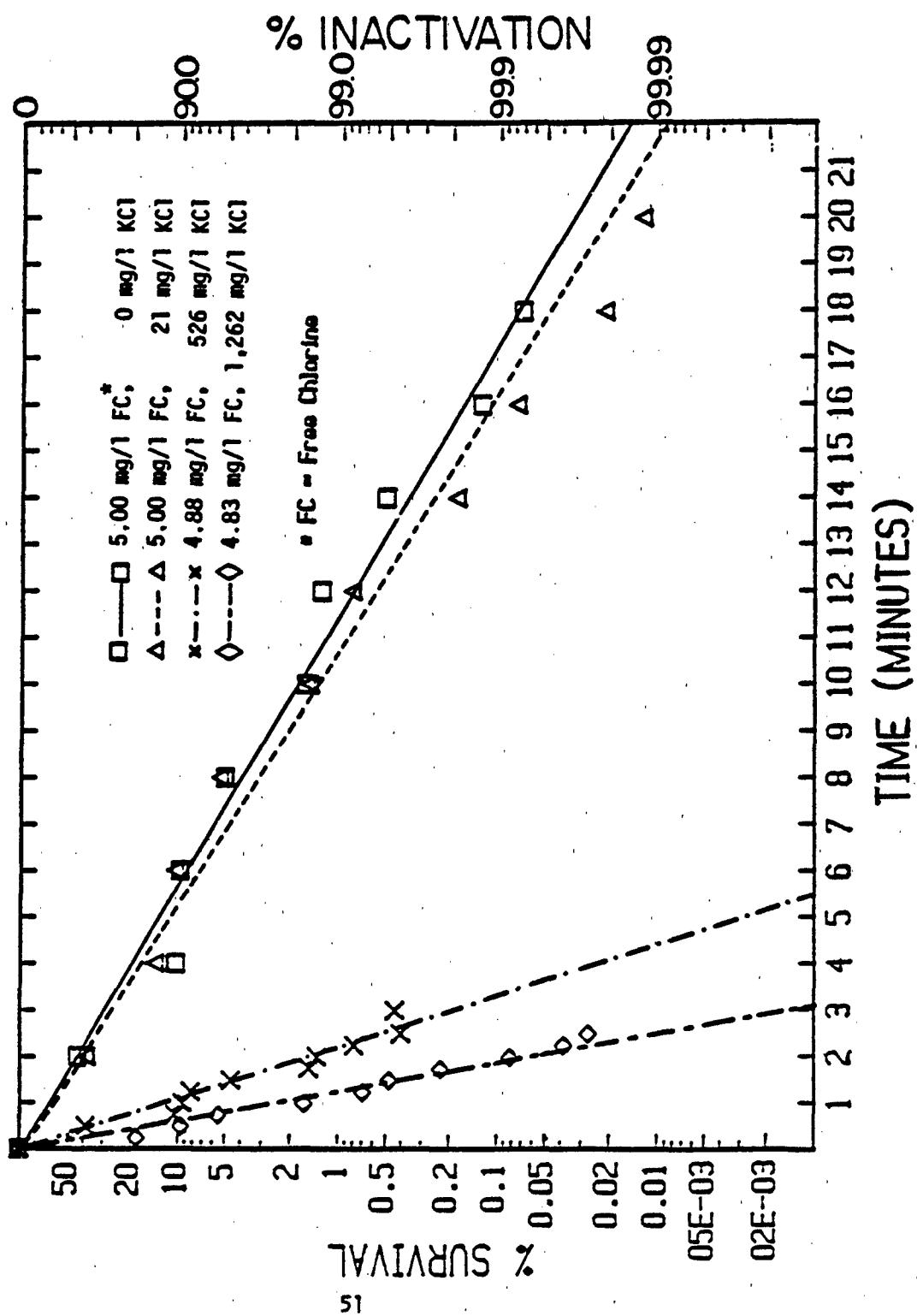


FIGURE 9. INACTIVATION OF POLIOVIRUS 1 AT 5°C IN NONBUFFERED
PURIFIED WATER AT pH 9.0 BY APPROXIMATELY 5 MG/L
OF FREE CHLORINE IN THE PRESENCE & ABSENCE OF KCL

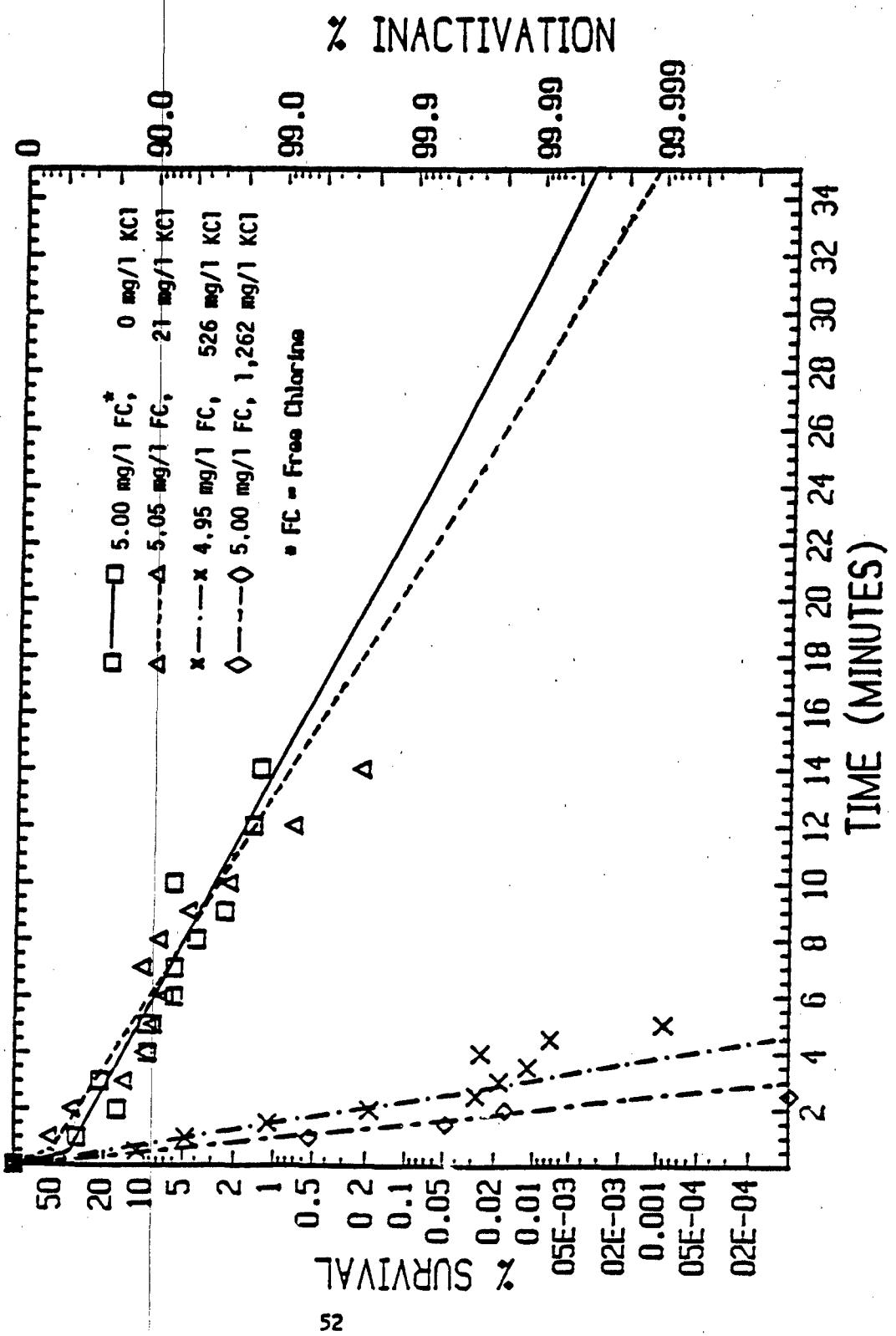


FIGURE 10. INACTIVATION OF POLIOVIRUS 1 AT 50°C IN NONBUFFERED TAP WATER AT pH 9.0 BY APPROXIMATELY 1 MG/L OF FREE CHLORINE IN THE PRESENCE AND ABSENCE OF KCL

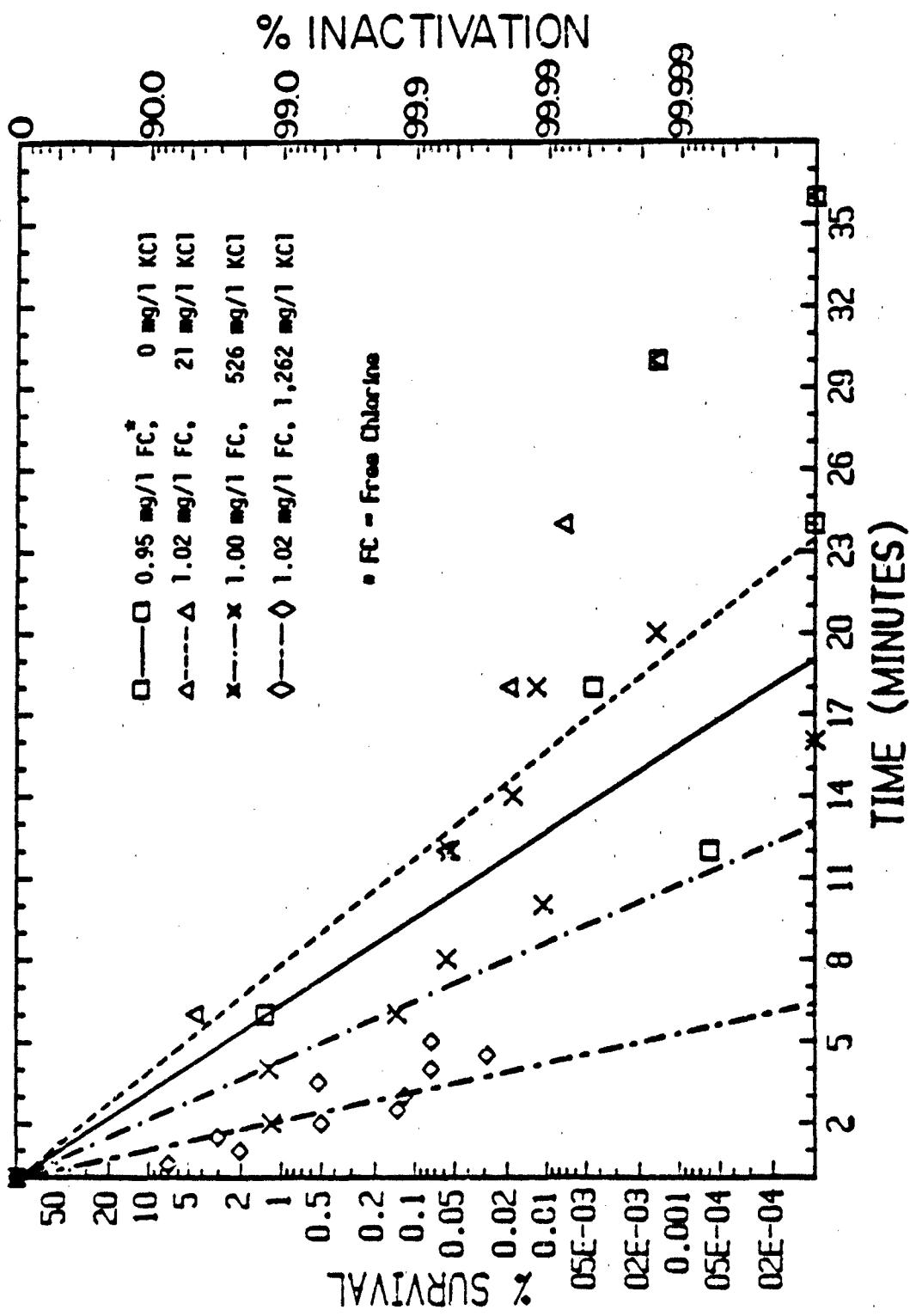


FIGURE 11. INACTIVATION OF POLIOVIRUS 1 AT 50°C IN NONBUFFERED TAP WATER AT pH 9.0 BY APPROXIMATELY 5 MG/L OF FREE CHLORINE IN THE PRESENCE AND ABSENCE OF KCL

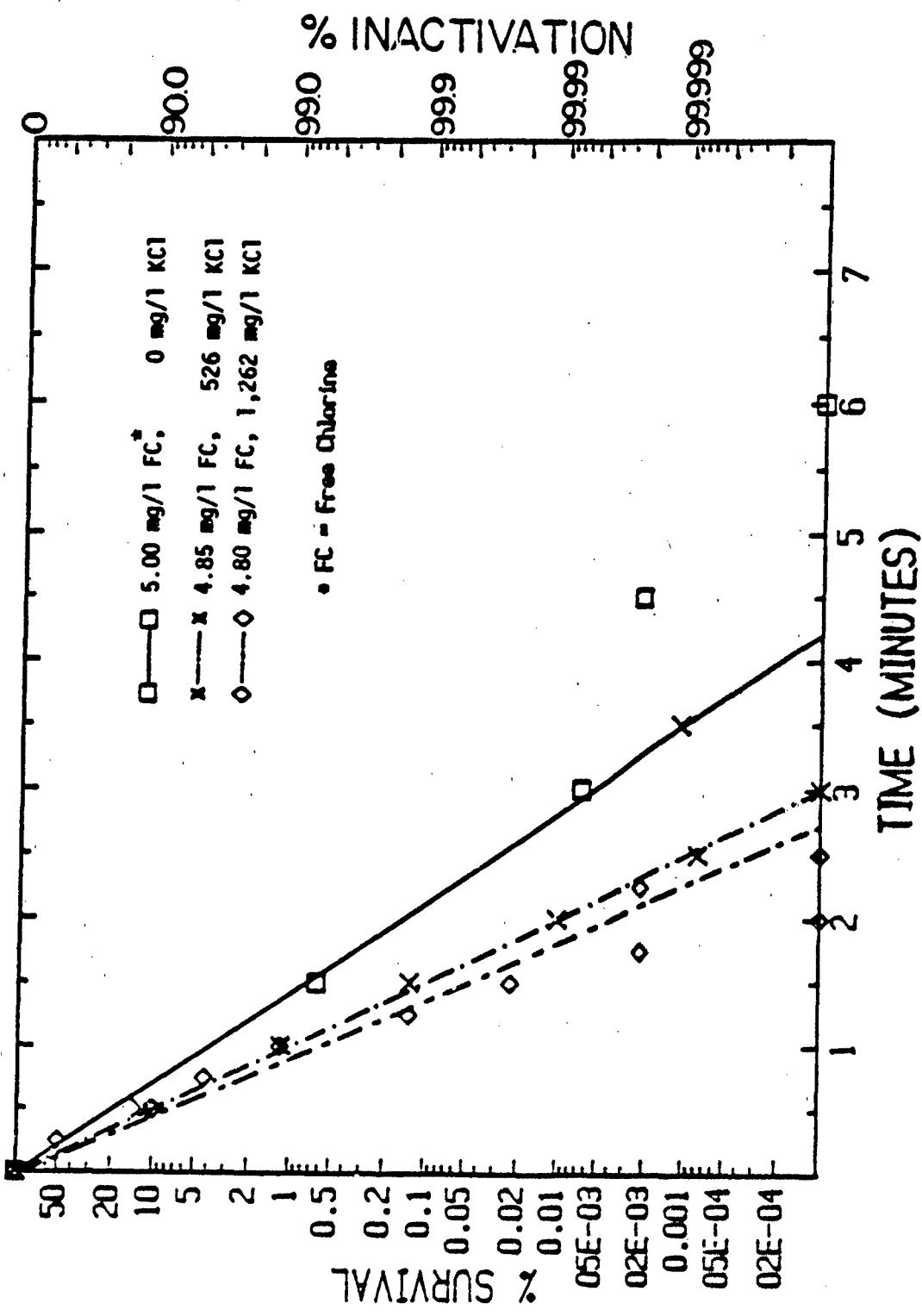


FIGURE 12. EFFECT OF Cl^- ON THE INACTIVATION OF POLIOVIRUS 1 (99.99%) AT 5OC BY FREE CHLORINE AT PH 4.5 IN PHthalate-Buffered Purified Water

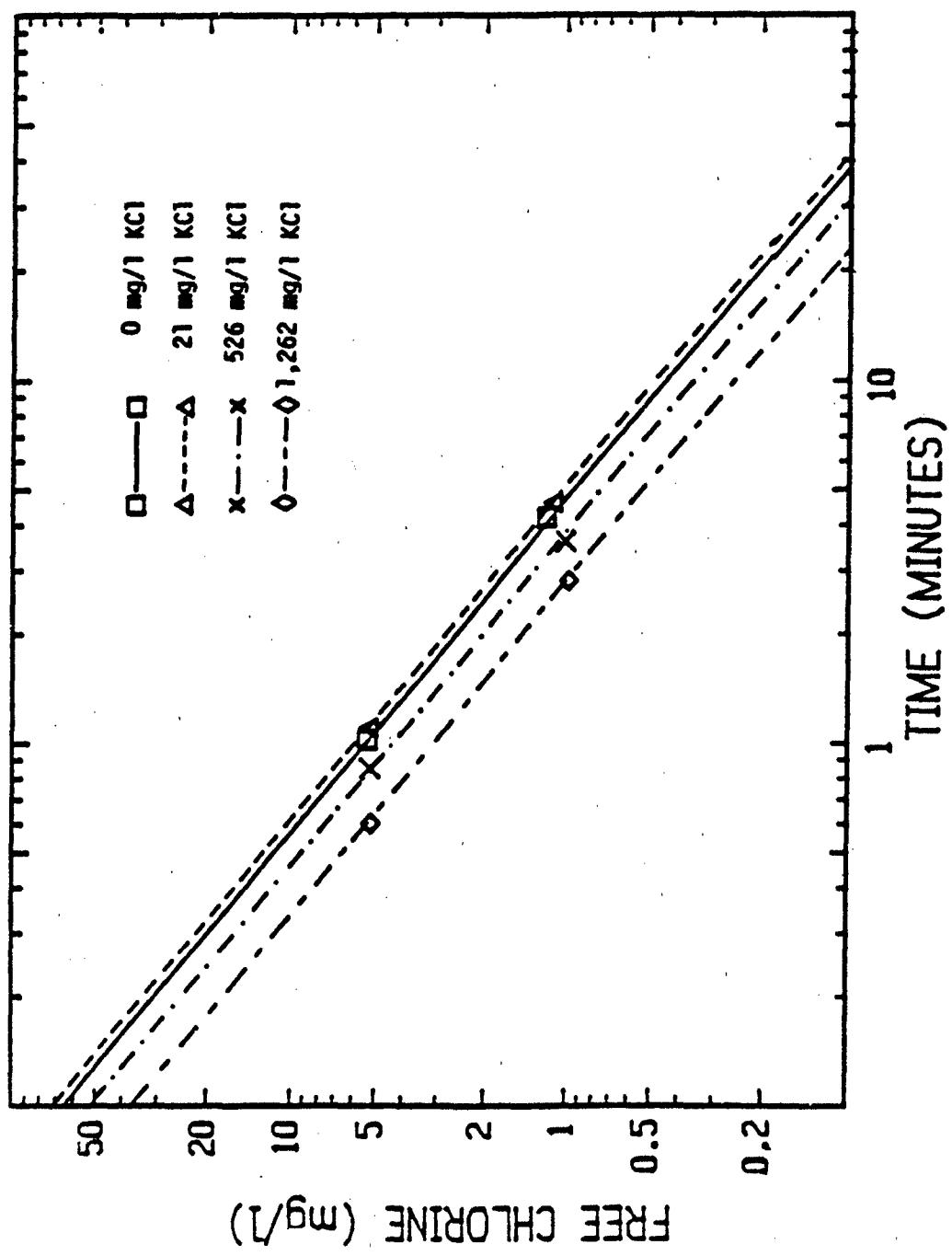


FIGURE 13. EFFECT OF KCL ON THE INACTIVATION OF POLIOVIRUS 1 (99,99%) AT 5°C BY FREE CHLORINE AT PH 9.0 IN BORATE-BUFFERED PURIFIED WATER

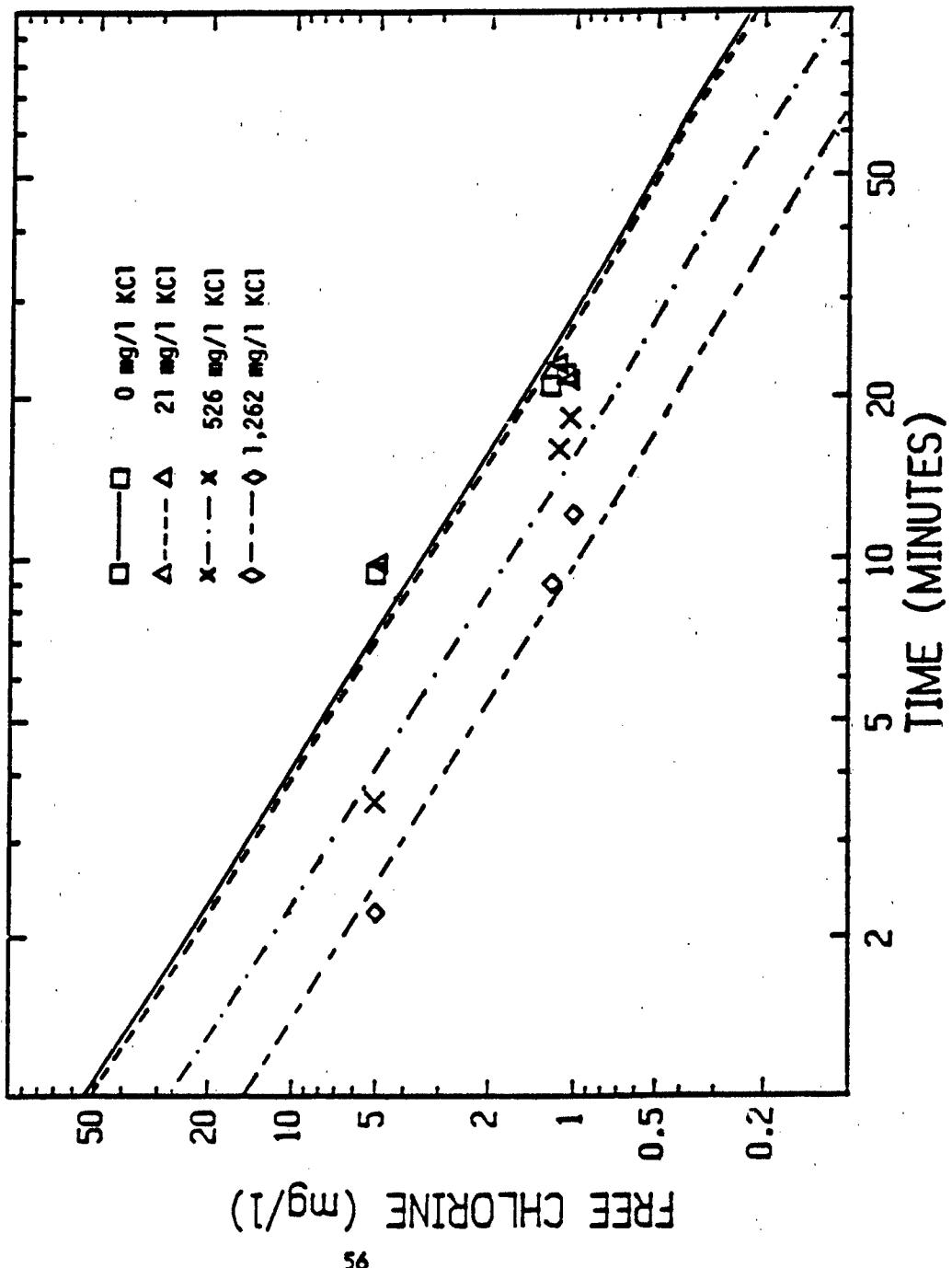


FIGURE 14. EFFECT OF KCL ON THE INACTIVATION OF POLIOVIRUS 1 (99.99%) AT 5°C BY FREE CHLORINE AT pH 9.0 IN NONBUFFERED PURIFIED WATER

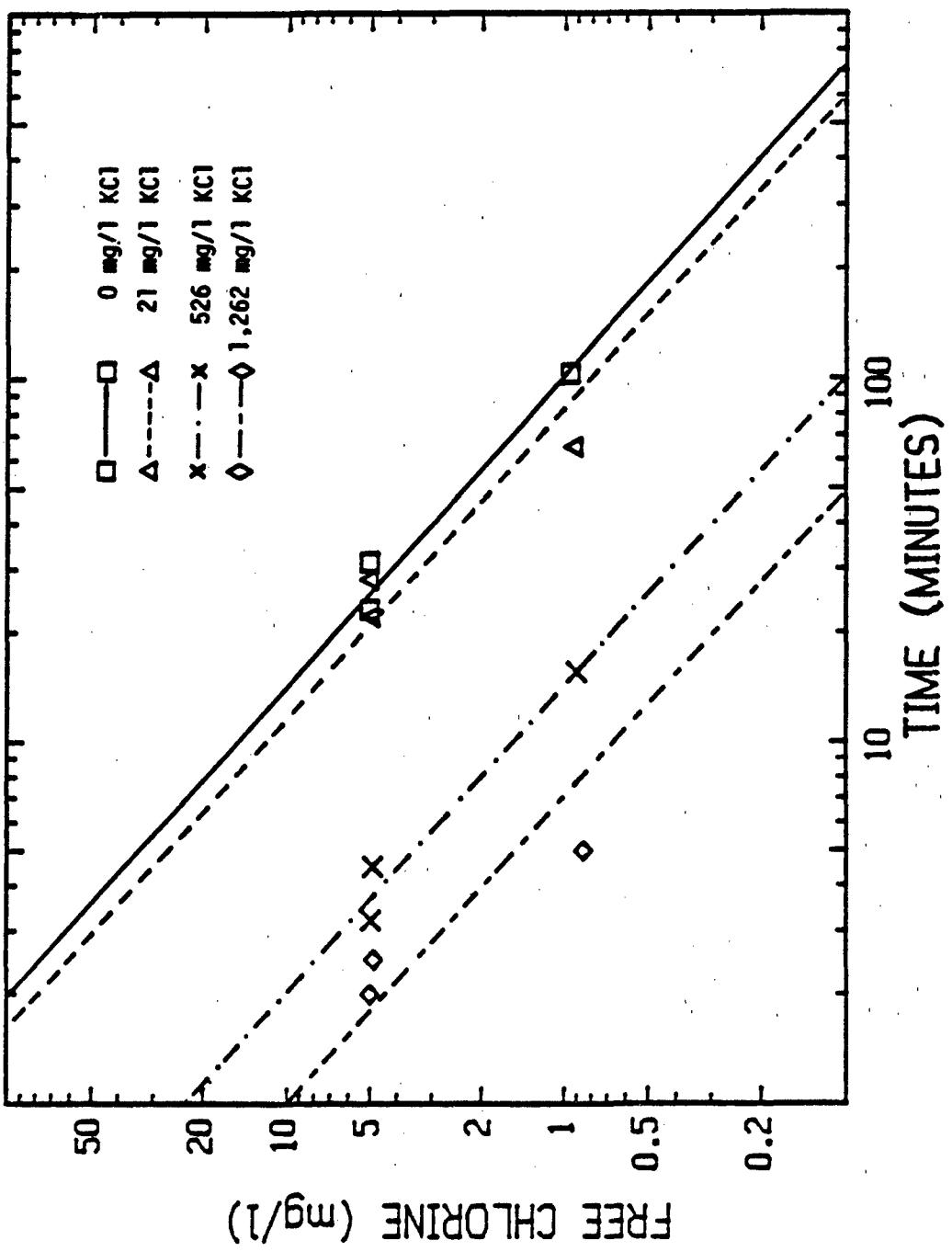


FIGURE 15. EFFECT OF 0.05 M BORATE BUFFER ON THE INACTIVATION OF
POLIOVIRUS 1 (99.9%) AT 5°C BY FREE CHLORINE AT PH 9.0

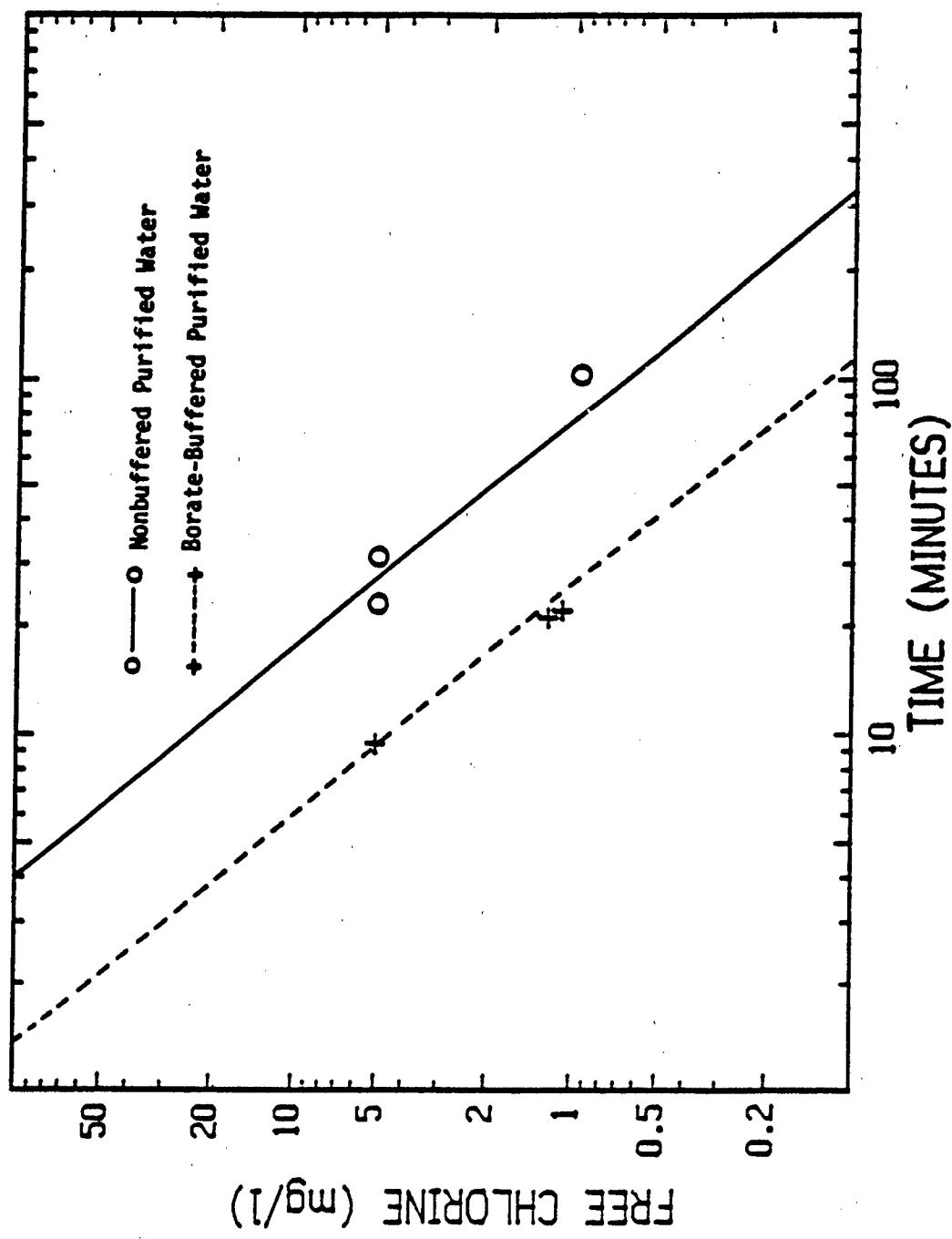


FIGURE 16. EFFECT OF KCL ON THE INACTIVATION OF POLIOVIRUS 1
(99.99%) AT 5°C BY FREE CHLORINE AT PH 9.0 IN
NONBUFFERED TAP WATER

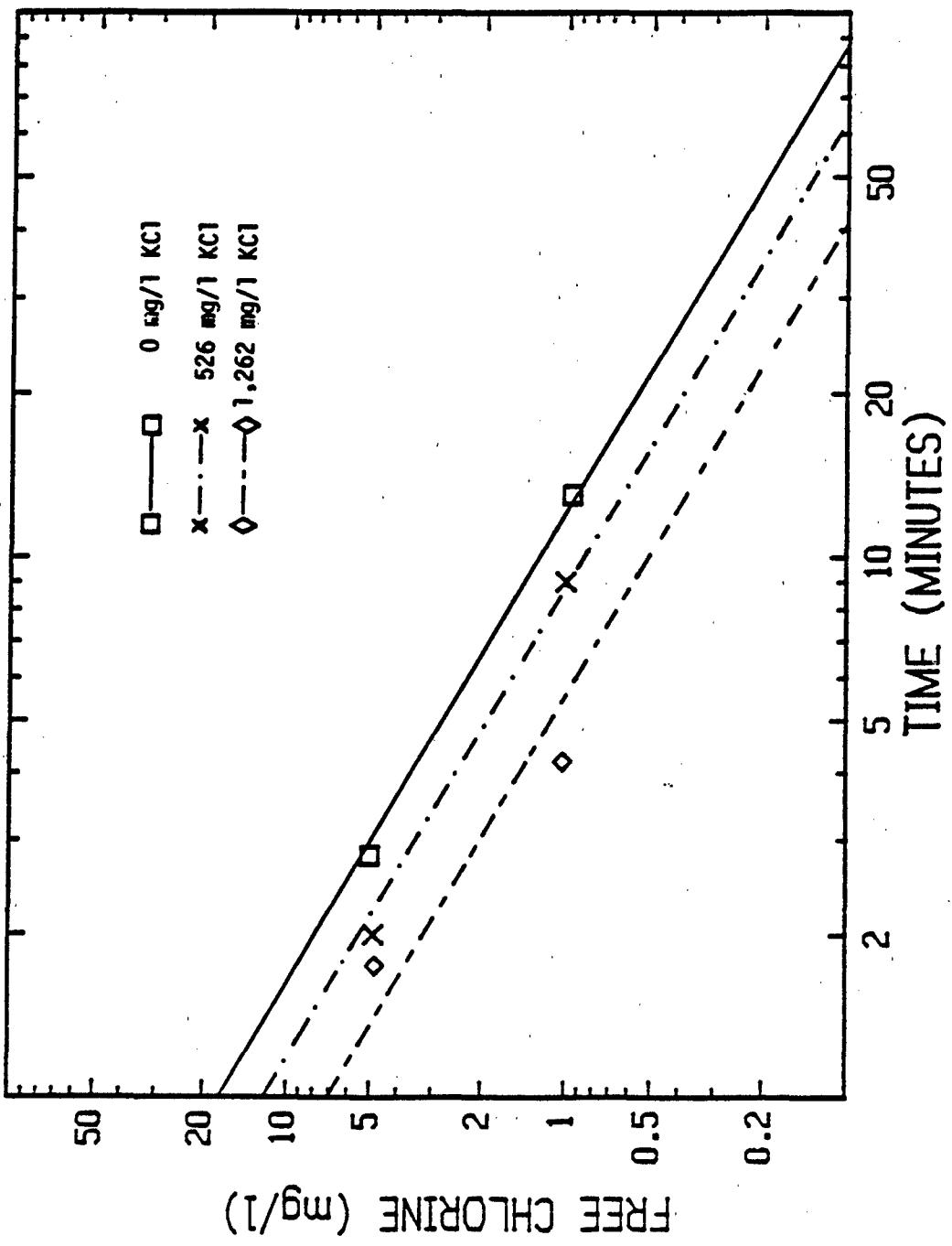
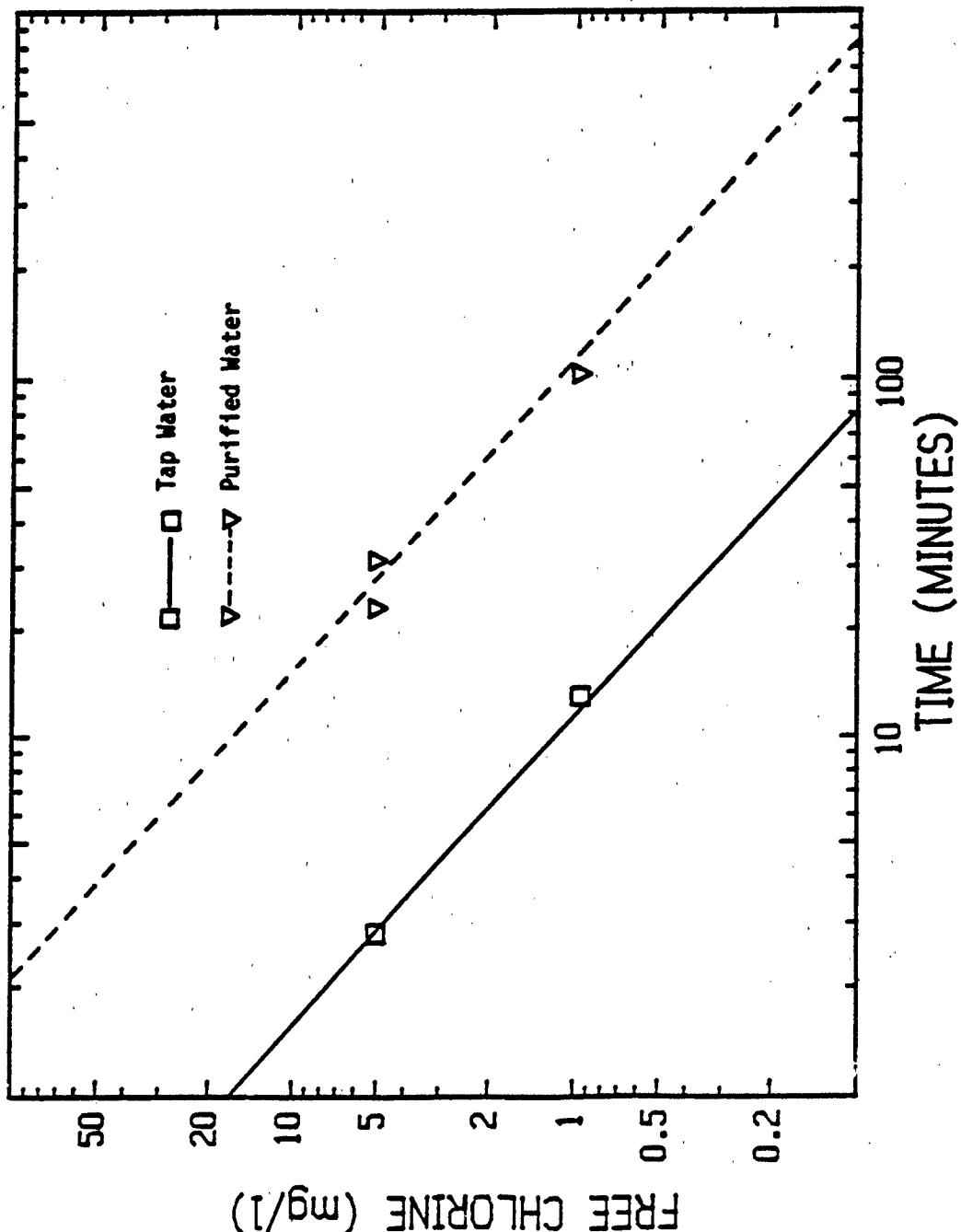


FIGURE 17. INACTIVATION OF POLIOVIRUS 1 (99.99%) AT 50°C BY FREE CHLORINE AT PH 5.0 IN NONBUFFERED PURIFIED WATER AND IN NONBUFFERED TAP WATER.



APPENDIX C
(LIST OF TABLES, pH 10.0])

TABLE A1. INACTIVATION OF POLIOVIRUS 1 AT 5°C IN BORATE-BUFFERED PURIFIED WATER AT pH 10.0 BY APPROXIMATELY 0.63-0.65 MG/L OF FREE CHLORINE IN THE PRESENCE AND ABSENCE OF KCL.

TEST # 1 CHLORINE (MG/L) : .65 KCL (MG/L) : 0 CONTROL (PFU/ML) : 152000
INITIAL CHLORINE (MG/L) : .67

TIME (MIN.)	SAMPLE 1 (PFU/ML)	SAMPLE 2 (PFU/ML)	AVERAGE (PFU/ML)	SURVIVAL (%)	INACTIVATION (%)
1	184000	184000	184000	121.0526	-21.0526
2	144000	104000	124000	81.5789	18.4211
3	144000	104000	124000	81.5789	18.4211
5	132000	116000	124000	81.5789	18.4211
8	116000	108000	112000	73.6842	26.3158
10	104000	108000	106000	69.7368	30.2632
15	104000	96000	100000	65.7894	34.2106
20	56000	36000	46000	30.2631	69.7369
25	37200	29200	33200	21.8421	78.1579
30	22800	25200	24000	15.7894	84.2106

TEST # 2 CHLORINE (MG/L) : .64 KCL (MG/L) : 21 CONTROL (PFU/ML) : 152000
INITIAL CHLORINE (MG/L) : .67

TIME (MIN.)	SAMPLE 1 (PFU/ML)	SAMPLE 2 (PFU/ML)	AVERAGE (PFU/ML)	SURVIVAL (%)	INACTIVATION (%)
1	152000	200000	176000	115.7894	-15.7894
2	224000	168000	186000	122.3684	-22.3684
3	160000	112000	136000	89.4736	10.5264
5	132000	104000	118000	77.6315	22.3685
8	120000	136000	128000	84.2105	15.7895
10	N/A	N/A	N/A	N/A	N/A
15	N/A	N/A	N/A	N/A	N/A
20	N/A	N/A	N/A	N/A	N/A
25	N/A	N/A	N/A	N/A	N/A
30	17600	16000	16800	11.0526	88.9474

TABLE A2. INACTIVATION OF POLIOVIRUS 1 AT 5°C IN BORATE-BUFFERED PURIFIED WATER
AT pH 10.0 BY APPROXIMATELY 0.63 MG/L OF FREE CHLORINE IN THE
PRESENCE AND ABSENCE OF KCL

TEST # 1 CHLORINE (MG/L) : .63 KCL (MG/L) : 526 CONTROL (PFU/ML) : 149000
INITIAL CHLORINE (MG/L) : .69

TIME (MIN.)	SAMPLE 1 (PFU/ML)	SAMPLE 2 (PFU/ML)	AVERAGE (PFU/ML)	SURVIVAL (%)	INACTIVATION (%)
1	N/A	N/A	N/A	N/A	N/A
2	N/A	N/A	N/A	N/A	N/A
3	N/A	N/A	N/A	N/A	N/A
5	N/A	N/A	N/A	N/A	N/A
8	N/A	N/A	N/A	N/A	N/A
10	N/A	N/A	N/A	N/A	N/A
15	20000	44000	32000	21.4765	78.5235
20	12000	12000	12000	8.0536	91.9464
25	20000	20000	20000	13.4228	86.5772
30	N/A	N/A	N/A	N/A	N/A

TEST # 2 CHLORINE (MG/L) : .62 KCL (MG/L) : 1,262 CONTROL (PFU/ML) : 149000
INITIAL CHLORINE (MG/L) : .69

TIME (MIN.)	SAMPLE 1 (PFU/ML)	SAMPLE 2 (PFU/ML)	AVERAGE (PFU/ML)	SURVIVAL (%)	INACTIVATION (%)
1	N/A	N/A	N/A	N/A	N/A
2	N/A	N/A	N/A	N/A	N/A
3	N/A	N/A	N/A	N/A	N/A
5	N/A	N/A	N/A	N/A	N/A
8	N/A	N/A	N/A	N/A	N/A
10	N/A	N/A	N/A	N/A	N/A
15	N/A	N/A	N/A	N/A	N/A
20	N/A	N/A	N/A	N/A	N/A
25	24000	36000	30000	20.1342	79.8658
30	4000	8000	6000	4.0268	95.9732

TABLE A3. INACTIVATION OF POLIOVIRUS 1 AT 5°C IN BORATE-BUFFERED PURIFIED WATER AT pH 10.0 BY APPROXIMATELY 1.3 MG/L OF FREE CHLORINE IN THE PRESENCE AND ABSENCE OF KCL

TEST # 1 CHLORINE (MG/L) : 1.27 KCL (MG/L) : 0 CONTROL (PFU/ML) : 178000
INITIAL CHLORINE (MG/L) : 1.3

TIME (MIN.)	SAMPLE 1 (PFU/ML)	SAMPLE 2 (PFU/ML)	AVERAGE (PFU/ML)	SURVIVAL (%)	INACTIVATION (%)
10	N/A	N/A	N/A	N/A	N/A
20	N/A	N/A	N/A	N/A	N/A
30	N/A	N/A	N/A	N/A	N/A
40	240	360	300	.1685	99.8315
50	N/A	N/A	N/A	N/A	N/A
60	N/A	N/A	N/A	N/A	N/A
70	N/A	N/A	N/A	N/A	N/A
80	N/A	N/A	N/A	N/A	N/A
90	56	20	38	.0213	99.9787
100	0	0	0	< 0.0001	> 99.9999

TEST # 2 CHLORINE (MG/L) : 1.22 KCL (MG/L) : 21 CONTROL (PFU/ML) : 178000
INITIAL CHLORINE (MG/L) : 1.3

TIME (MIN.)	SAMPLE 1 (PFU/ML)	SAMPLE 2 (PFU/ML)	AVERAGE (PFU/ML)	SURVIVAL (%)	INACTIVATION (%)
10	N/A	N/A	N/A	N/A	N/A
20	36000	52000	44000	24.7191	75.2809
30	2000	0	1000	.5617	99.4383
40	800	400	600	.337	99.663
50	80	120	100	.0561	99.9439
60	80	40	60	.0337	99.9663
70	40	40	40	.0224	99.9776
80	N/A	N/A	N/A	N/A	N/A
90	160	0	80	.0449	99.9551
100	28	0	14	7.8E-03	99.9922

TABLE A4. INACTIVATION OF POLIOVIRUS 1 AT 5°C IN BORATE-BUFFERED PURIFIED WATER
AT pH 10.0 BY APPROXIMATELY 5.63-5.69 MG/L OF FREE CHLORINE IN THE
PRESENCE AND ABSENCE OF KCL

TEST # 1 CHLORINE (MG/L) : 5.63 KCL (MG/L) : 0 CONTROL (PFU/ML) : 143000
INITIAL CHLORINE (MG/L) : 5.55

TIME (MIN.)	SAMPLE 1 (PFU/ML)	SAMPLE 2 (PFU/ML)	AVERAGE (PFU/ML)	SURVIVAL (%)	INACTIVATION (%)
1.5	64000	56000	60000	41.958	58.042
3	28000	32000	30000	20.979	79.021
4.5	6400	10400	8400	5.8741	94.1259
6	920	960	940	.6573	99.3427
7.5	880	800	840	.5874	99.4126
9	40	72	56	.0391	99.9609
10.5	28	16	22	.0153	99.9847
12	16	4	10	6.9E-03	99.9931
13.5	8	8	8	5.5E-03	99.9945
15	24	24	24	.0167	99.9833

TEST # 2 CHLORINE (MG/L) : 5.64 KCL (MG/L) : 21 CONTROL (PFU/ML) : 143000
INITIAL CHLORINE (MG/L) : 5.55

TIME (MIN.)	SAMPLE 1 (PFU/ML)	SAMPLE 2 (PFU/ML)	AVERAGE (PFU/ML)	SURVIVAL (%)	INACTIVATION (%)
1.5	52000	32000	42000	29.3706	70.6294
3	64000	48000	56000	39.1608	60.8392
4.5	8000	8000	8000	5.5944	94.4056
6	2800	5200	4000	2.7972	97.2028
7.5	600	600	600	.4195	99.5805
9	440	400	420	.2937	99.7063
10.5	112	100	105	.0741	99.9259
12	20	32	26	.0181	99.9819
13.5	32	12	22	.0153	99.9847
15	32	16	24	.0167	99.9833

TABLE A4. (Continued)

TEST # 3 CHLORINE (MG/L) : 5.69 KCL (MG/L) : 526 CONTROL (PFU/ML) : 143000
 INITIAL CHLORINE (MG/L) : 5.55

TIME (MIN.)	SAMPLE 1 (PFU/ML)	SAMPLE 2 (PFU/ML)	AVERAGE (PFU/ML)	SURVIVAL (%)	INACTIVATION (%)
1.5	84000	44000	64000	44.7552	55.2448
3	72000	40000	56000	39.1608	60.8392
4.5	11600	6800	9200	6.4335	93.5665
6	1800	1600	1700	1.1888	98.8112
7.5	144	32	88	.0615	99.9385
9	40	28	34	.0237	99.9763
10.5	20	36	28	.0195	99.9805
12	20	12	16	.0111	99.9889
13.5	16	12	14	9.7E-03	99.9903
15	12	16	14	9.7E-03	99.9903

TEST # 4 CHLORINE (MG/L) : 5.64 KCL (MG/L) : 1,262 CONTROL (PFU/ML) : 143000
 INITIAL CHLORINE (MG/L) : 5.55

TIME (MIN.)	SAMPLE 1 (PFU/ML)	SAMPLE 2 (PFU/ML)	AVERAGE (PFU/ML)	SURVIVAL (%)	INACTIVATION (%)
1.5	60000	48000	54000	37.7622	62.2378
3	520	360	540	.3776	99.6224
4.5	100	132	116	.0811	99.9189
6	44	48	46	.0321	99.9679
7.5	32	36	34	.0237	99.9763
9	36	36	36	.0251	99.9749
10.5	0	0	0	< 0.0001	> 99.9999
12	12	12	6	4.1E-03	99.9959
13.5	12	12	12	8.3E-03	99.9917
15	12	8	10	6.9E-03	99.9931

TABLE A5A. INACTIVATION OF POLIOVIRUS 1 AT 5°C IN BORATE-BUFFERED PURIFIED WATER AT pH 10.0 BY APPROXIMATELY 0.81-0.83 MG/L OF FREE CHLORINE IN THE PRESENCE AND ABSENCE OF KCL

TEST # 1 CHLORINE (MG/L) : .81 KCL (MG/L) : 1.262 CONTROL (PFU/ML) : 214000
INITIAL CHLORINE (MG/L) : .9

TIME (MIN.)	SAMPLE 1 (PFU/ML)	SAMPLE 2 (PFU/ML)	AVERAGE (PFU/ML)	SURVIVAL (%)	INACTIVATION (%)
10	128000	104000	116000	54.2056	45.7944
20	120000	84000	102000	47.6635	52.3365
30	68000	44000	56000	26.1682	73.8318
40	24000	48000	36000	16.8224	83.1776001
50	8400	6000	7200	3.3644	96.6356
60	160	800	480	.2242	99.7758
70	68	68	68	.0317	99.9683
80	8	4	6	2.8E-03	99.9972
90	4	8	6	2.8E-03	99.9972
100	16	16	16	7.4E-03	99.9926

TEST # 4 CHLORINE (MG/L) : .83 KCL (MG/L) : 0 CONTROL (PFU/ML) : 161000
INITIAL CHLORINE (MG/L) : .9

TIME (MIN.)	SAMPLE 1 (PFU/ML)	SAMPLE 2 (PFU/ML)	AVERAGE (PFU/ML)	SURVIVAL (%)	INACTIVATION (%)
10	68000	44000	56000	34.7826	65.2174001
20	44000	60000	52000	32.2981	67.7019
30	15600	13600	14600	9.0683	90.9317
40	4000	5200	4500	2.8571	97.1429
50	1160	1680	1420	.8819	99.1181
60	280	240	260	.1614	99.8386
70	96	76	86	.0534	99.9466
80	80	44	62	.0385	99.9613
90	72	40	56	.0347	99.9653
100	40	24	32	.0198	99.9802

TABLE A5B. INACTIVATION OF POLIOVIRUS 1 AT 5°C IN BORATE-BUFFERED PURIFIED WATER AT pH 10.0 BY APPROXIMATELY 0.61-0.77 MG/L OF FREE CHLORINE IN THE PRESENCE AND ABSENCE OF KCL

TEST # 2 CHLORINE (MG/L) : .61 KCL (MG/L) : 3,728 CONTROL (PFU/ML) : 214000
INITIAL CHLORINE (MG/L) : .9

TIME (MIN.)	SAMPLE 1 (PFU/ML)	SAMPLE 2 (PFU/ML)	AVERAGE (PFU/ML)	SURVIVAL (%)	INACTIVATION (%)
.5	108000	136000	122000	57.0093	42.9907
1	96000	164000	130000	60.7476	39.2524
1.5	116000	104000	110000	51.4018	48.5982
2	160000	148000	154000	71.9626	28.0374
3	140000	124000	132000	61.6822	38.3178
4	76000	108000	92000	42.9906	57.0094
5	96000	96000	96000	44.5598	55.1402
6	120000	128000	124000	57.9439	42.0561
7	116000	104000	110000	51.4018	48.5982
8	48000	80000	64000	29.9065	70.0935

TEST # 3 CHLORINE (MG/L) : .77 KCL (MG/L) : 3,728 CONTROL (PFU/ML) : 161000
INITIAL CHLORINE (MG/L) : .9

TIME (MIN.)	SAMPLE 1 (PFU/ML)	SAMPLE 2 (PFU/ML)	AVERAGE (PFU/ML)	SURVIVAL (%)	INACTIVATION (%)
.5	120000	72000	96000	59.6273	40.3727
1	112000	124000	118000	73.2919	26.7081
1.5	60000	88000	74000	45.9627	54.0373
2	84000	84000	84000	52.1739	47.8261
3	84000	64000	74000	45.9627	54.0373
4	64000	80000	72000	44.7204	55.2796
5	44000	80000	62000	38.5093	61.4907
6	60000	56000	58000	36.0248	63.9752
7	60000	60000	60000	37.267	62.733
8	80000	44000	62000	38.5093	61.4907

TABLE A6. INACTIVATION OF POLIOVIRUS 1 AT 5°C IN BORATE-BUFFERED PURIFIED WATER
AT pH 10.0 BY APPROXIMATELY 0.60-1.30 MG/L OF FREE CHLORINE IN THE
PRESENCE AND ABSENCE OF KCL

TEST # 1 CHLORINE (MG/L) : 1.19 KCL (MG/L) : 7,456 CONTROL (PFU/ML) : 181000
INITIAL CHLORINE (MG/L) : 1.5

TIME (MIN.)	SAMPLE 1 (PFU/ML)	SAMPLE 2 (PFU/ML)	AVERAGE (PFU/ML)	SURVIVAL (%)	INACTIVATION (%)
.5	N/A	N/A	N/A	N/A	N/A
1	104000	104000	104000	57.4585	42.5415
1.5	N/A	N/A	N/A	N/A	N/A
2	92000	92000	92000	50.8287	49.1713
5	100000	120000	110000	60.7734	39.2266
10	104000	104000	104000	57.4585	42.5415
20	5200	8800	7000	3.8674	96.1326
30	36	52	44	.0243	99.9757
40	52	52	52	.0287	99.9713
50	16	24	20	.011	99.989

TEST # 2 CHLORINE (MG/L) : .6 KCL (MG/L) : 7,456 CONTROL (PFU/ML) : 181000
INITIAL CHLORINE (MG/L) : 1.5

TIME (MIN.)	SAMPLE 1 (PFU/ML)	SAMPLE 2 (PFU/ML)	AVERAGE (PFU/ML)	SURVIVAL (%)	INACTIVATION (%)
.5	N/A	N/A	N/A	N/A	N/A
1	N/A	N/A	N/A	N/A	N/A
1.5	N/A	N/A	N/A	N/A	N/A
2	N/A	N/A	N/A	N/A	N/A
5	108000	108000	108000	59.6685	40.3315
10	108000	108000	108000	59.6685	40.3315
20	100000	100000	100000	55.2486	44.7514
30	60000	44000	52000	28.7292	71.2708
40	4400	7200	5800	3.2044	96.7956
50	440	520	480	.2651	99.7349

TABLE A6. (Continued)

TEST # 3 CHLORINE (MG/L) : 1.11 KCL (MG/L) : 7.456 CONTROL (PFU/ML) : 107000
 INITIAL CHLORINE (MG/L) : 1.5

TIME (MIN.)	SAMPLE 1 (PFU/ML)	SAMPLE 2 (PFU/ML)	AVERAGE (PFU/ML)	SURVIVAL (%)	INACTIVATION (%)
.5	88000	88000	88000	82.2429	17.7571
1	124000	96000	110000	102.8037	-2.8037
1.5	N/A	N/A	N/A	N/A	N/A
2	60000	96000	78000	72.8971	27.1029
5	60000	48000	54000	50.4672	49.5328
10	60000	56000	58000	54.2056	45.7944
20	720	600	660	.6168	99.3832
30	120	120	120	.1121	99.8879
40	40	72	56	.0523	99.9477
50	28	44	36	.0336	99.9664

TEST # 4 CHLORINE (MG/L) : 1.3 KCL (MG/L) : 0 CONTROL (PFU/ML) : 107000
 INITIAL CHLORINE (MG/L) : 1.5

TIME (MIN.)	SAMPLE 1 (PFU/ML)	SAMPLE 2 (PFU/ML)	AVERAGE (PFU/ML)	SURVIVAL (%)	INACTIVATION (%)
10	40000	20000	30000	28.0373	71.9627
20	44000	44000	44000	41.1214	58.8786
30	12400	8400	10400	9.7196	90.2804
40	960	840	900	.8411	99.1589
50	60	40	50	.0467	99.9533
60	32	52	42	.0392	99.9608
70	32	44	38	.0355	99.9645
80	28	16	22	.0205	99.9795
90	28	28	28	.0261	99.9739
100	8	8	8	7.4E-03	99.9926

TABLE A7. INACTIVATION OF POLIOVIRUS 1 AT 5°C IN BORATE-BUFFERED PURIFIED WATER AT pH 10.0 BY APPROXIMATELY 0.65-4.21 MG/L OF FREE CHLORINE IN THE PRESENCE AND ABSENCE OF KCL

TEST # 1 CHLORINE (MG/L) : .65 KCL (MG/L) : 7.456 CONTROL (PFU/ML) : 8200
INITIAL CHLORINE (MG/L) : .98

TIME (MIN.)	SAMPLE 1 (PFU/ML)	SAMPLE 2 (PFU/ML)	AVERAGE (PFU/ML)	SURVIVAL (%)	INACTIVATION (%)
.5	3600	4000	3800	46.3414	53.6586
1	3600	3200	3400	41.4634	58.5366
1.5	4800	1600	3200	39.0243	60.9757
2	2400	3200	2800	34.1463	65.8537001
5	680	640	660	8.0487	91.9513
10	N/A	N/A	N/A	N/A	N/A
20	32	32	32	.3902	99.6098
30	0	0	0	< 0.0001	> 99.9999
40	0	0	0	< 0.0001	> 99.9999
50	0	0	0	< 0.0001	> 99.9999

TEST # 2 CHLORINE (MG/L) : .73 KCL (MG/L) : 0 CONTROL (PFU/ML) : 8200
INITIAL CHLORINE (MG/L) : .98

TIME (MIN.)	SAMPLE 1 (PFU/ML)	SAMPLE 2 (PFU/ML)	AVERAGE (PFU/ML)	SURVIVAL (%)	INACTIVATION (%)
.5	10000	8400	9200	112.1951	-12.1951
1	11200	8000	9600	117.0731	-17.0731
1.5	4800	1600	3200	39.0243	60.9757
2	6400	3200	4800	58.5365	41.4635
5	3200	800	2000	24.3902	75.6098
10	N/A	N/A	N/A	N/A	N/A
20	2400	2000	2200	26.8292	73.1708
30	200	120	160	1.9512	98.0488
40	36	60	48	.5853	99.4147
50	16	8	12	.1463	99.8537

TABLE A7. (Continued)

TEST # 3 CHLORINE (MG/L) : 3.9 KCL (MG/L) : 7.456 CONTROL (PFU/ML) : 10500
 INITIAL CHLORINE (MG/L) : .98

TIME (MIN.)	SAMPLE 1 (PFU/ML)	SAMPLE 2 (PFU/ML)	AVERAGE (PFU/ML)	SURVIVAL (%)	INACTIVATION (%)
.5	3200	4000	3600	34.2857	65.7143
1	800	2800	1800	17.1428	82.8572
1.5	800	1200	1000	9.5238	90.4762
2	320	360	340	3.238	96.762
4	40	56	48	.4571	99.5429
6	48	32	40	.3809	99.6191
8	4	4	4	.038	99.962
10	0	0	0	< 0.0001	> 99.9999
12	0	0	0	< 0.0001	> 99.9999
14	0	0	0	< 0.0001	> 99.9999

TEST # 4 CHLORINE (MG/L) : 4.21 KCL (MG/L) : 0 CONTROL (PFU/ML) : 10500
 INITIAL CHLORINE (MG/L) : .98

TIME (MIN.)	SAMPLE 1 (PFU/ML)	SAMPLE 2 (PFU/ML)	AVERAGE (PFU/ML)	SURVIVAL (%)	INACTIVATION (%)
.5	8800	6400	7600	72.3809	27.6191
1	4400	4000	4200	40	60
1.5	2800	3200	3000	28.5714	71.4286001
2	3200	2800	3000	28.5714	71.4286001
4	2000	2400	2200	20.9523	79.0477
6	360	600	480	4.5714	95.4286
8	280	280	280	2.6666	97.3334
10	68	84	76	.7238	99.2762
12	24	28	26	.2476	99.7524
14	8	4	6	.0571	99.9429

TABLE A8. INACTIVATION OF POLIOVIRUS 1 AT 5°C IN BORATE-BUFFERED PURIFIED WATER AT pH 10.0 BY APPROXIMATELY 0.95-1.15 MG/L OF FREE CHLORINE IN THE PRESENCE AND ABSENCE OF KCL

TEST # 1 CHLORINE (MG/L) : 1.15 KCL (MG/L) : 0 CONTROL (PFU/ML) : 181000
INITIAL CHLORINE (MG/L) : 1.21

TIME (MIN.)	SAMPLE 1 (PFU/ML)	SAMPLE 2 (PFU/ML)	AVERAGE (PFU/ML)	SURVIVAL (%)	INACTIVATION (%)
5	168000	156000	162000	89.5027	10.4973
10	72000	64000	68000	37.569	62.431
15	68000	48000	58000	32.0441	67.9559
20	40000	72000	56000	30.9392	69.0608001
25	8400	9600	9000	4.9723	95.0277
30	4000	5600	4800	2.6519	97.3481
35	1360	1360	1360	.7513	99.2487
40	560	560	560	.3093	99.6907
45	116	116	116	.064	99.936
50	72	72	72	.0397	99.9603

TEST # 2 CHLORINE (MG/L) : .95 KCL (MG/L) : 7,456 CONTROL (PFU/ML) : 181000
INITIAL CHLORINE (MG/L) : 1.21

TIME (MIN.)	SAMPLE 1 (PFU/ML)	SAMPLE 2 (PFU/ML)	AVERAGE (PFU/ML)	SURVIVAL (%)	INACTIVATION (%)
3	40000	32000	36000	19.8895	80.1105
6	920	1160	1040	.5745	99.4255
9	360	440	400	.2209	99.7791
12	360	360	360	.1988	99.8012
15	280	240	260	.1436	99.8564
18	84	104	94	.0519	99.9481
21	8400	8400	8400	4.6408	95.3592
24	68	72	70	.0386	99.9614
27	68	60	64	.0353	99.9647
30	56	36	46	.0254	99.9746

TABLE 8. (Continued)

TEST # 3 CHLORINE (MG/L) : 1.13 KCL (MG/L) : 21 CONTROL (PFU/ML) : 181000
 INITIAL CHLORINE (MG/L) : 1.21

TIME (MIN.)	SAMPLE 1 (PFU/ML)	SAMPLE 2 (PFU/ML)	AVERAGE (PFU/ML)	SURVIVAL (%)	INACTIVATION (%)
4	28000	44000	36000	19.8895	80.1105
8	12800	15600	14200	7.8453	92.1547
12	11600	14800	13200	7.2928	92.7072
16	12000	10800	11400	6.2983	93.7017
20	6800	9600	8200	4.5303	95.4697
24	1600	2000	1800	.9944	99.0036
28	1520	1120	1320	.7292	99.2708
32	560	800	680	.3756	99.6244
36	132	56	94	.0519	99.9481
40	108	140	124	.0685	99.9315

TEST # 4 CHLORINE (MG/L) : 1.05 KCL (MG/L) : 1,262 CONTROL (PFU/ML) : 181000
 INITIAL CHLORINE (MG/L) : 1.21

TIME (MIN.)	SAMPLE 1 (PFU/ML)	SAMPLE 2 (PFU/ML)	AVERAGE (PFU/ML)	SURVIVAL (%)	INACTIVATION (%)
4	32000	28000	30000	16.5745	83.4255
8	1200	3200	2200	1.2154	98.7846
12	240	280	260	.1436	99.8564
16	200	320	260	.1436	99.8564
20	104	72	88	.0486	99.9514
24	64	44	54	.0298	99.9702
28	64	68	66	.0364	99.9636
32	44	40	42	.0232	99.9768
36	36	44	40	.022	99.978
40	36	32	34	.0187	99.9813

TABLE A9. INACTIVATION OF POLIOVIRUS 1 AT 5°C IN BORATE-BUFFERED PURIFIED WATER AT pH 10.0 BY APPROXIMATELY 4.63-4.76 MG/L OF FREE CHLORINE IN THE PRESENCE AND ABSENCE OF KCL

TEST # 1 CHLORINE (MG/L) : 4.75 KCL (MG/L) : 0 CONTROL (PFU/ML) : 155500
INITIAL CHLORINE (MG/L) : 4.88

TIME (MIN.)	SAMPLE 1 (PFU/ML)	SAMPLE 2 (PFU/ML)	AVERAGE (PFU/ML)	SURVIVAL (%)	INACTIVATION (%)
1	N/A	N/A	N/A	N/A	N/A
2	92000	124000	108000	69.4533	30.5467
4	72000	80000	76000	48.8745	51.1255
6	40000	48000	44000	28.2958	71.7042
8	40000	20000	30000	19.2926	80.7074
10	8000	28000	18000	11.5755	88.4245
12	5200	5600	5400	3.4726	96.5274
14	0	400	200	.1286	99.8714
16	400	120	260	.1672	99.8328
18	28	16	22	.0141	99.9859

TEST # 2 CHLORINE (MG/L) : 4.72 KCL (MG/L) : 21 CONTROL (PFU/ML) : 155500
INITIAL CHLORINE (MG/L) : 4.88

TIME (MIN.)	SAMPLE 1 (PFU/ML)	SAMPLE 2 (PFU/ML)	AVERAGE (PFU/ML)	SURVIVAL (%)	INACTIVATION (%)
1	112000	60000	86000	55.3054	44.6946
2	100000	88000	94000	60.4501	39.5499
4	52000	28000	40000	25.7234	74.2766
6	452	44000	22226	14.2932	85.7068
8	32000	32000	32000	20.5787	79.4213
10	8000	16000	12000	7.717	92.283
12	7200	3200	5200	3.344	96.656
14	640	520	580	.3729	99.6271
16	12	44	28	.018	99.982
18	4	8	6	3.8E-03	99.9962

APPENDIX D
(LIST OF FIGURES (pH 10.0))

FIGURE 11. INACTIVATION OF RHOVIRUS 1 AT 57°C IN BURKE-BURKE PURIFIED WATER AT pH 10.0 BY APPROXIMATELY 0.63-0.65 MG/L OF FREE CHLORINE IN THE PRESENCE AND ABSENCE OF KCL

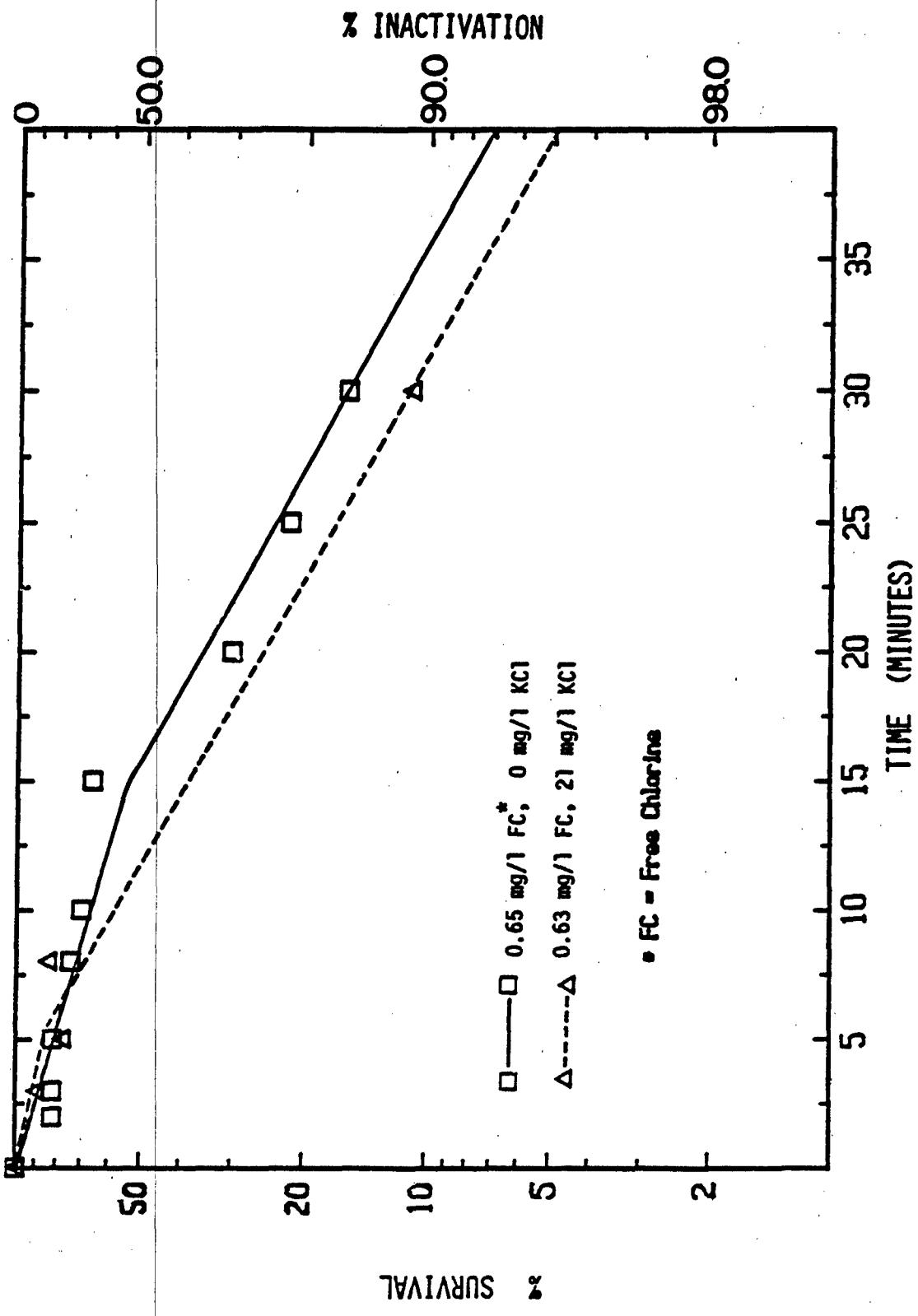
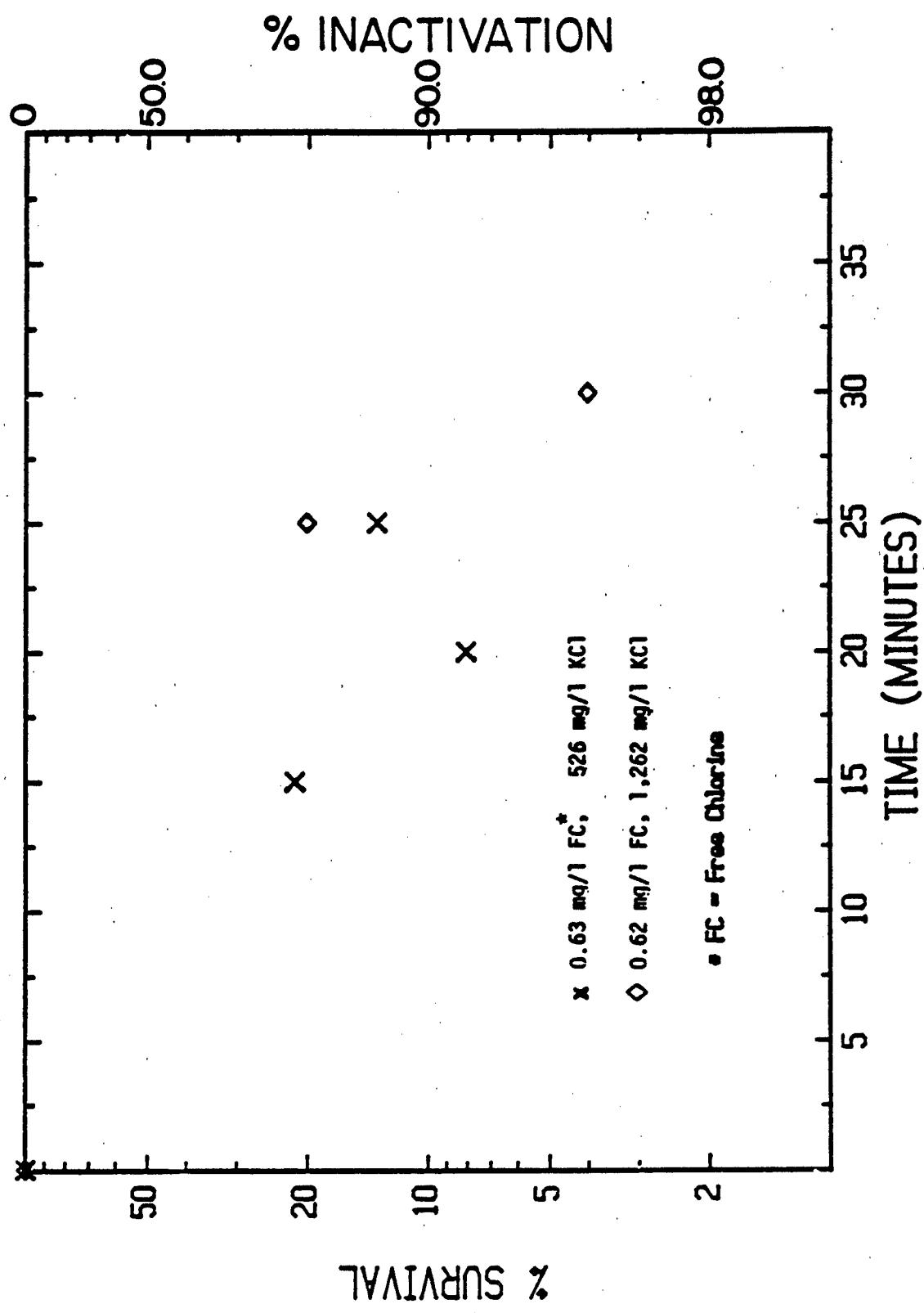


FIGURE A2. INACTIVATION OF POLIOVIRUS 1 AT 5°C IN BORATE-BUFFERED PURIFIED WATER AT pH 10.0 BY APPROXIMATELY 0.63 MG/L OF FREE CHLORINE IN THE PRESENCE AND ABSENCE OF KCL



PURIFIED WATER AT pH 10.0 BY APPROXIMATELY 1.3 MG/L OF FREE CHLORINE IN THE PRESENCE AND ABSENCE OF KCL

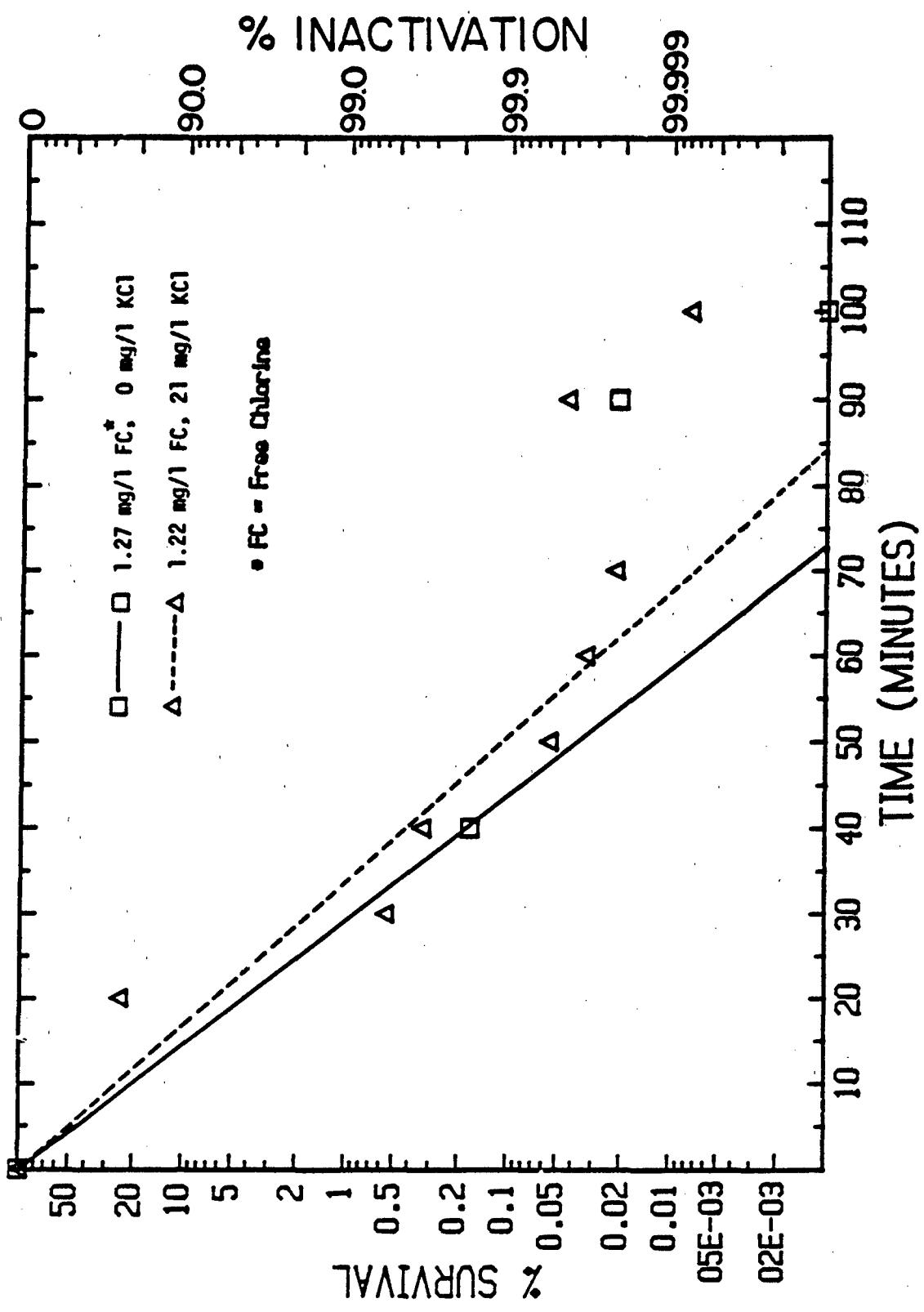


FIGURE A4. INACTIVATION OF POLIOVIRUS 1 AT 50°C IN BORATE-BUFFERED PURIFIED WATER AT pH 10.0 BY APPROXIMATELY 5.6-5.69 MG/L OF FREE CHLORINE IN THE PRESENCE AND ABSENCE OF KCl

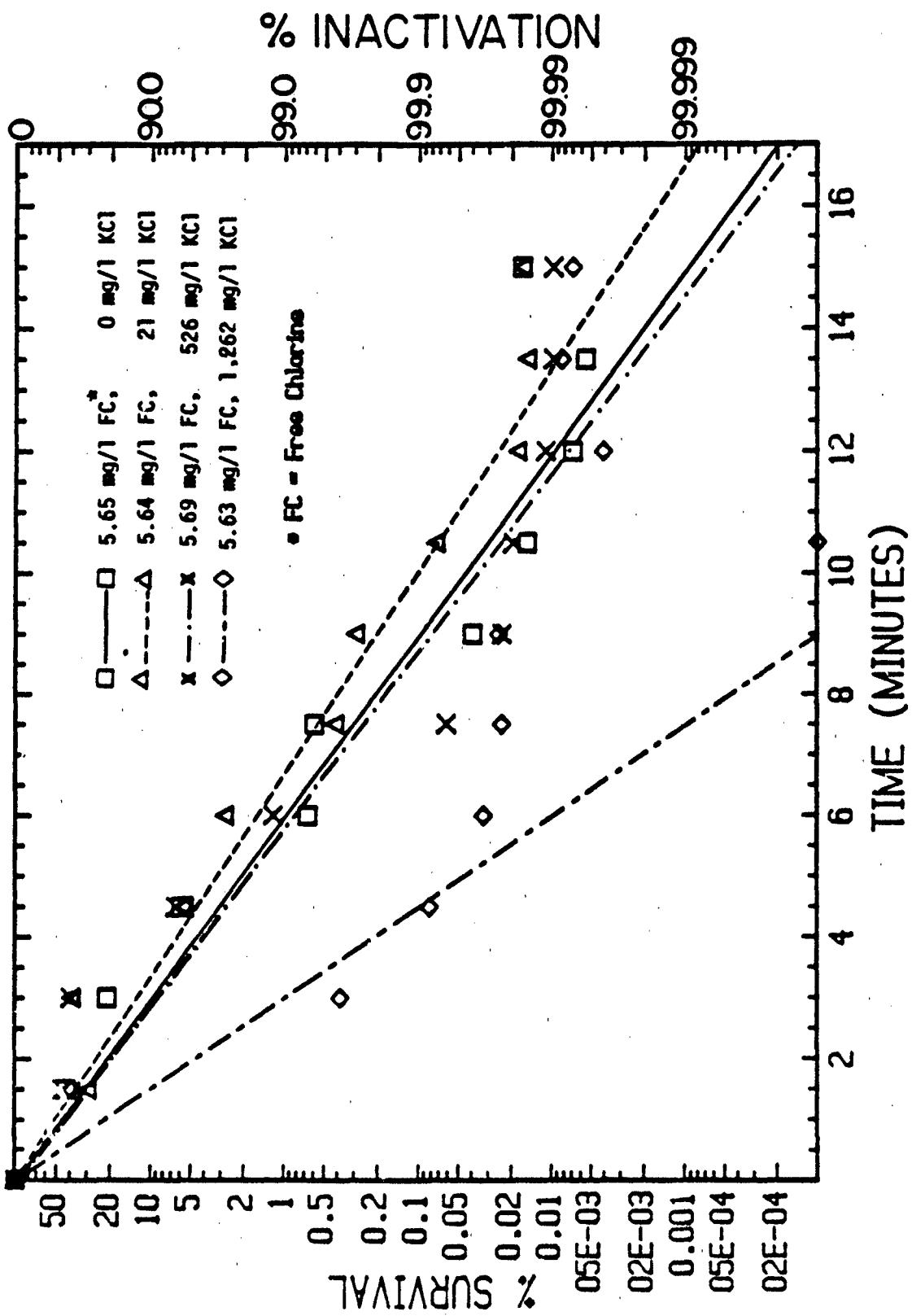


FIGURE A5A. INACTIVATION OF POLIOVIRUS 1 AT 50°C IN BORATE-BUFFERED PURIFIED WATER AT pH 10.0 BY APPROXIMATELY 0.81-0.83 MG/L OF FREE CHLORINE IN THE PRESENCE AND ABSENCE OF KCL

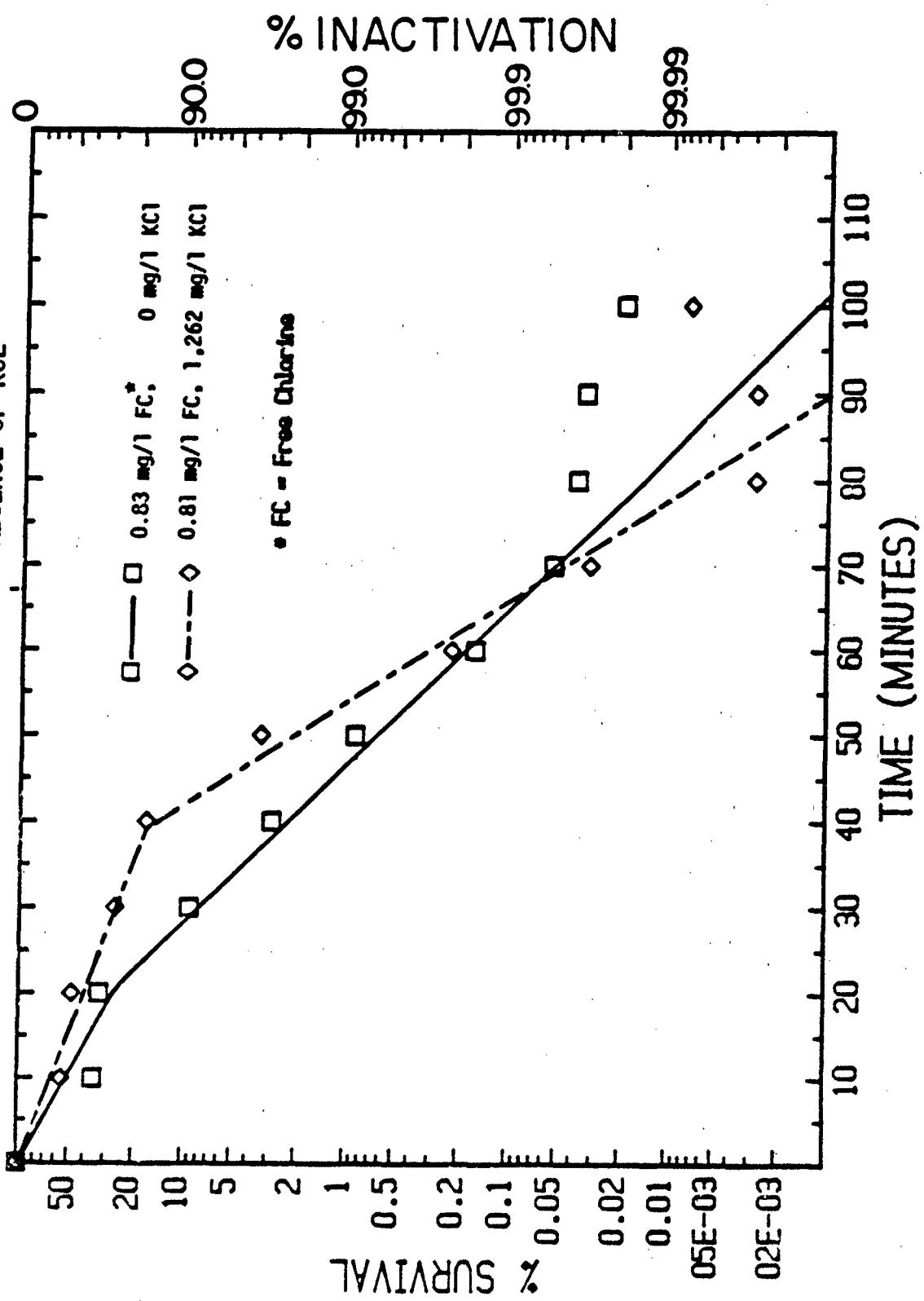


FIGURE A5B. INACTIVATION OF POLIOVIRUS 1 AT 50°C IN BORATE-BUFFERED PURIFIED WATER AT pH 10.0 BY APPROXIMATELY 0.61-0.77 MG/L OF FREE CHLORINE IN THE PRESENCE AND ABSENCE OF KCL

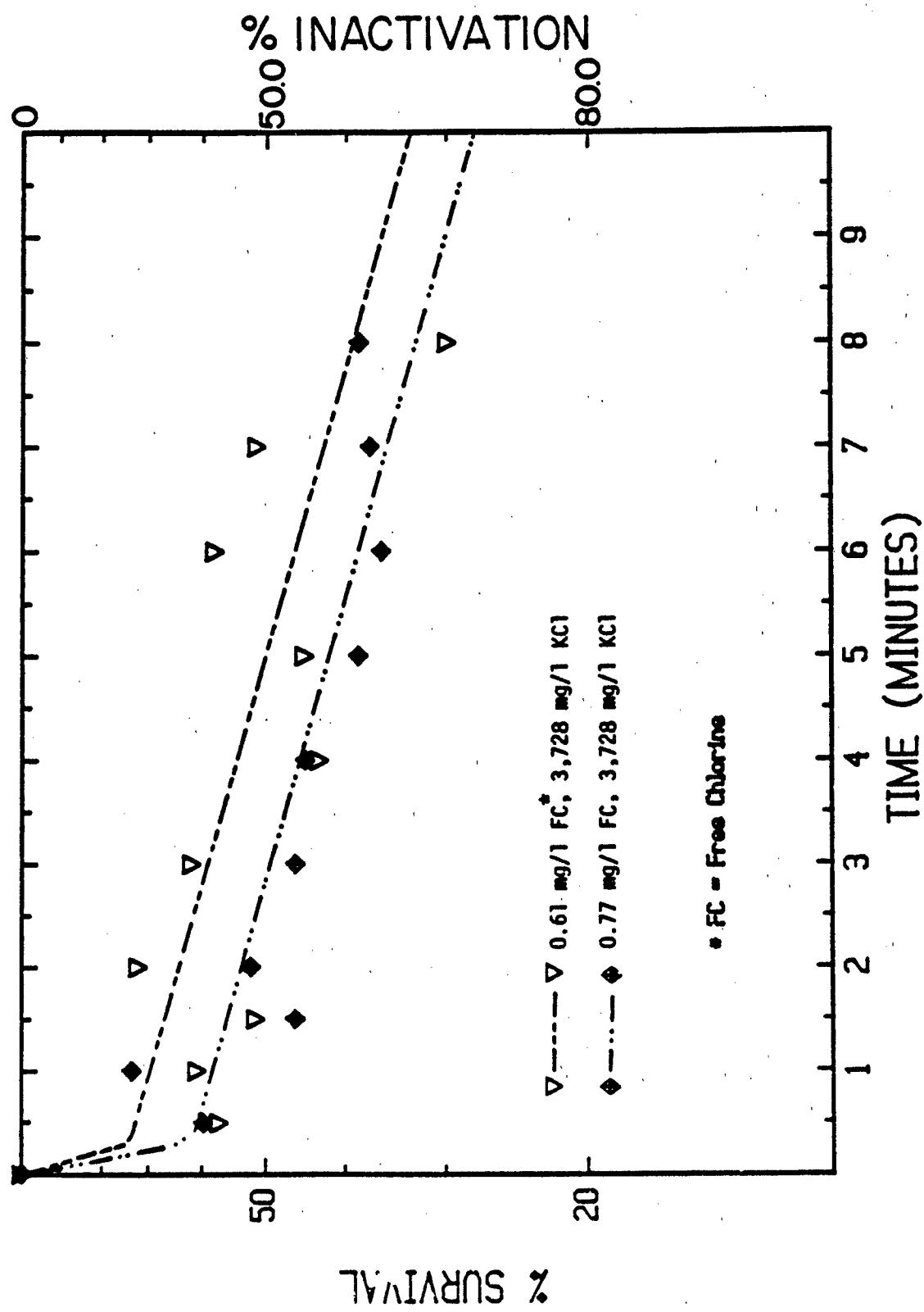


FIGURE A6. INACTIVATION OF POLIOVIRUS 1 AT 5°C IN BORATE-BUFFERED PURIFIED WATER AT pH 10.0 BY APPROXIMATELY 0.60-1.30 MG/L OF FREE CHLORINE IN THE PRESENCE AND ABSENCE OF KCL

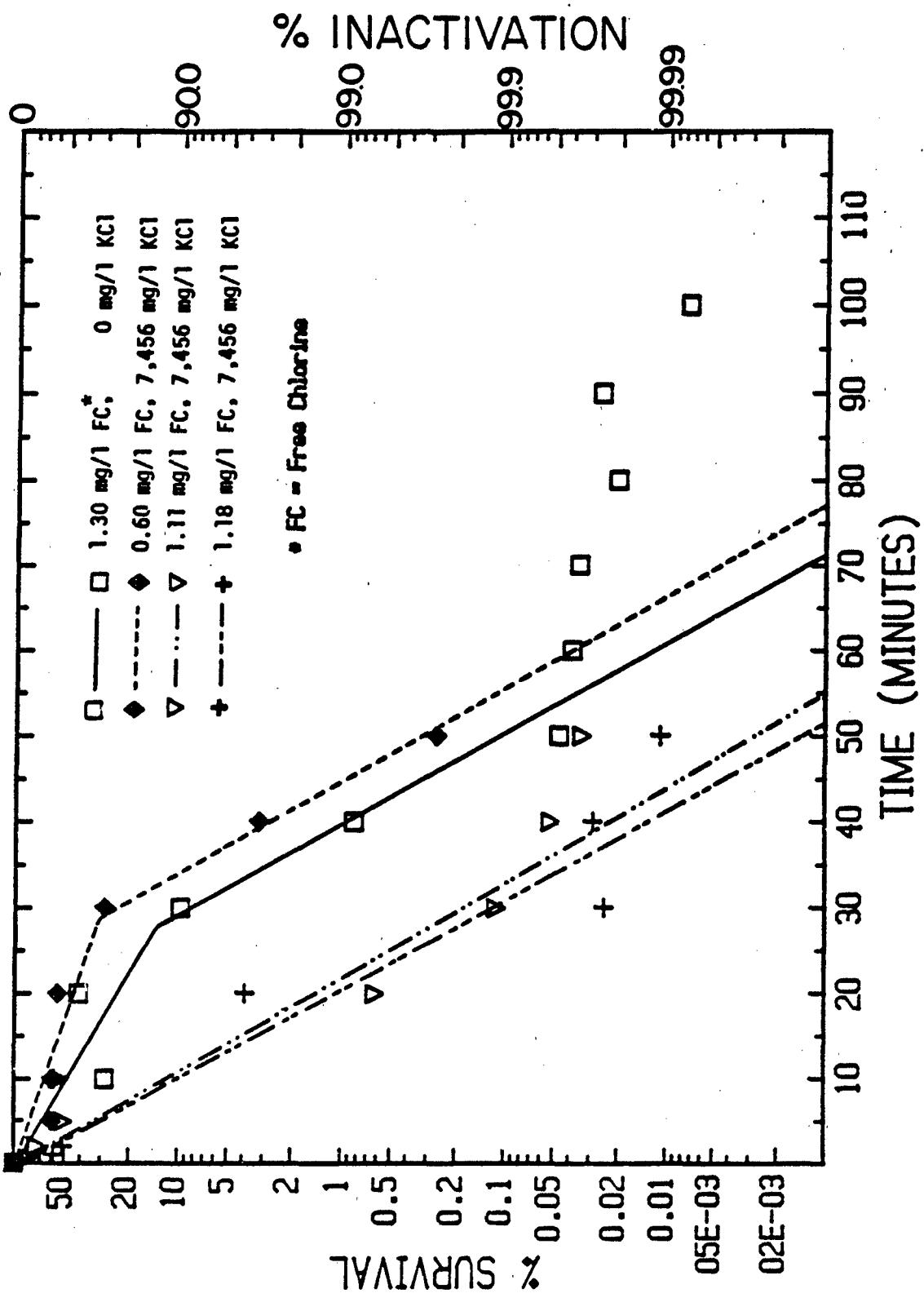


FIGURE A7. INACTIVATION OF POLIOVIRUS 1 AT 50°C IN BORATE-BUFFERED PURIFIED WATER AT pH 10.0 BY APPROXIMATELY 0.65-4.21 MG/L OF FREE CHLORINE IN THE PRESENCE AND ABSENCE OF KCL

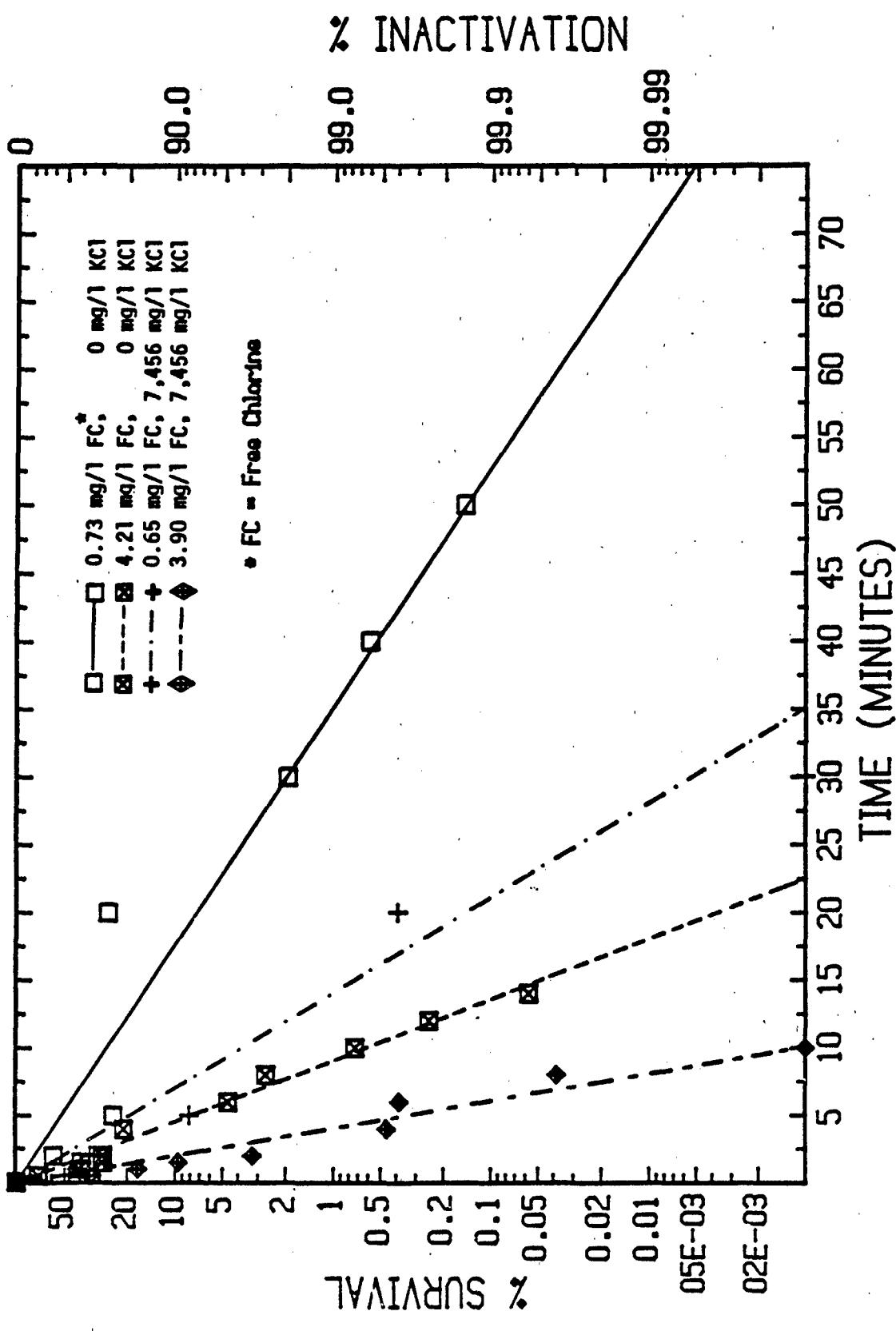


FIGURE A8. INACTIVATION OF POLIOVIRUS 1 AT 50°C IN BORATE-BUFFERED PURIFIED WATER AT pH 10.0 BY APPROXIMATELY 0, 95-1.15 MG/L OF FREE CHLORINE IN THE PRESENCE AND ABSENCE OF KCL

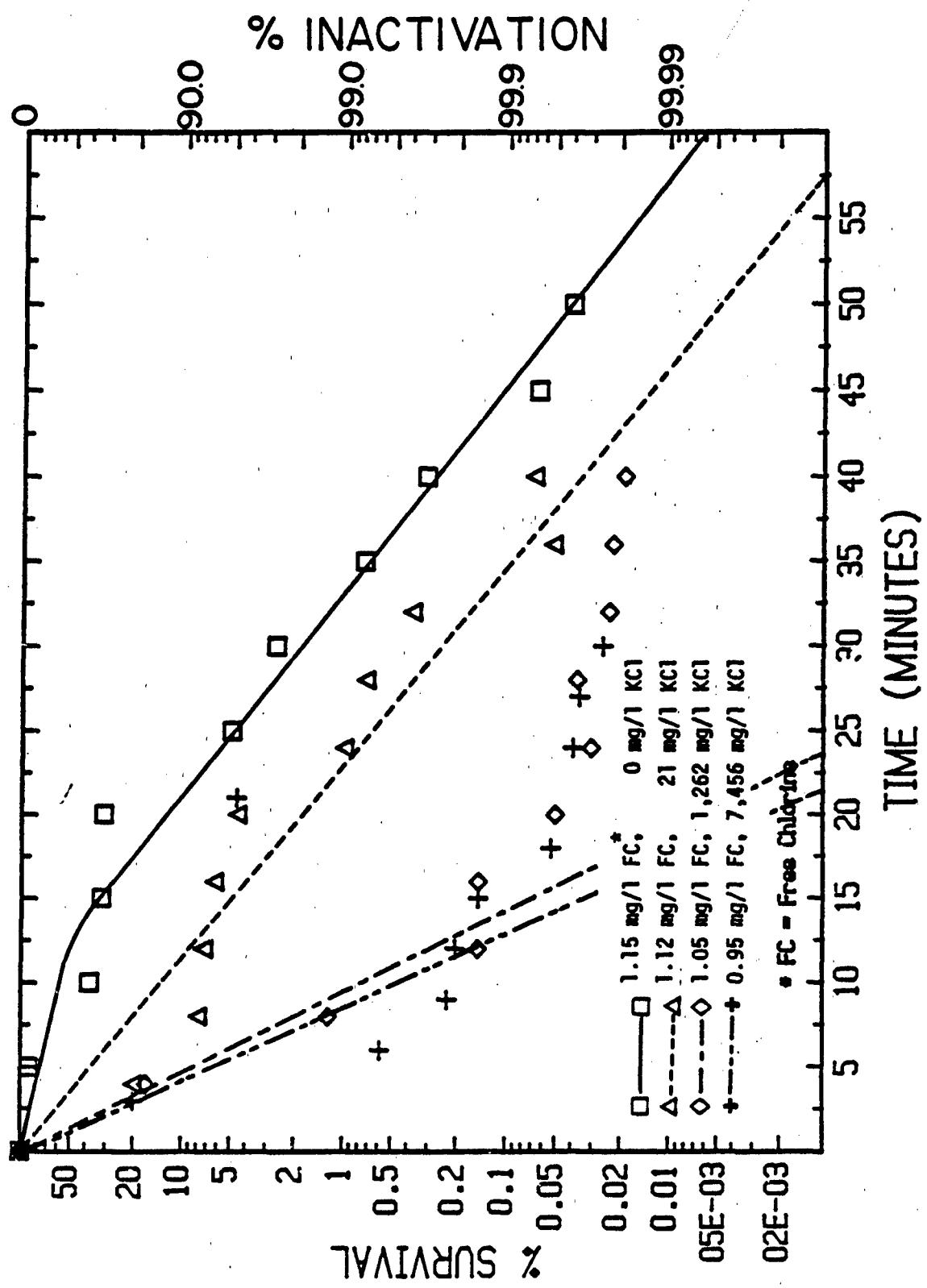
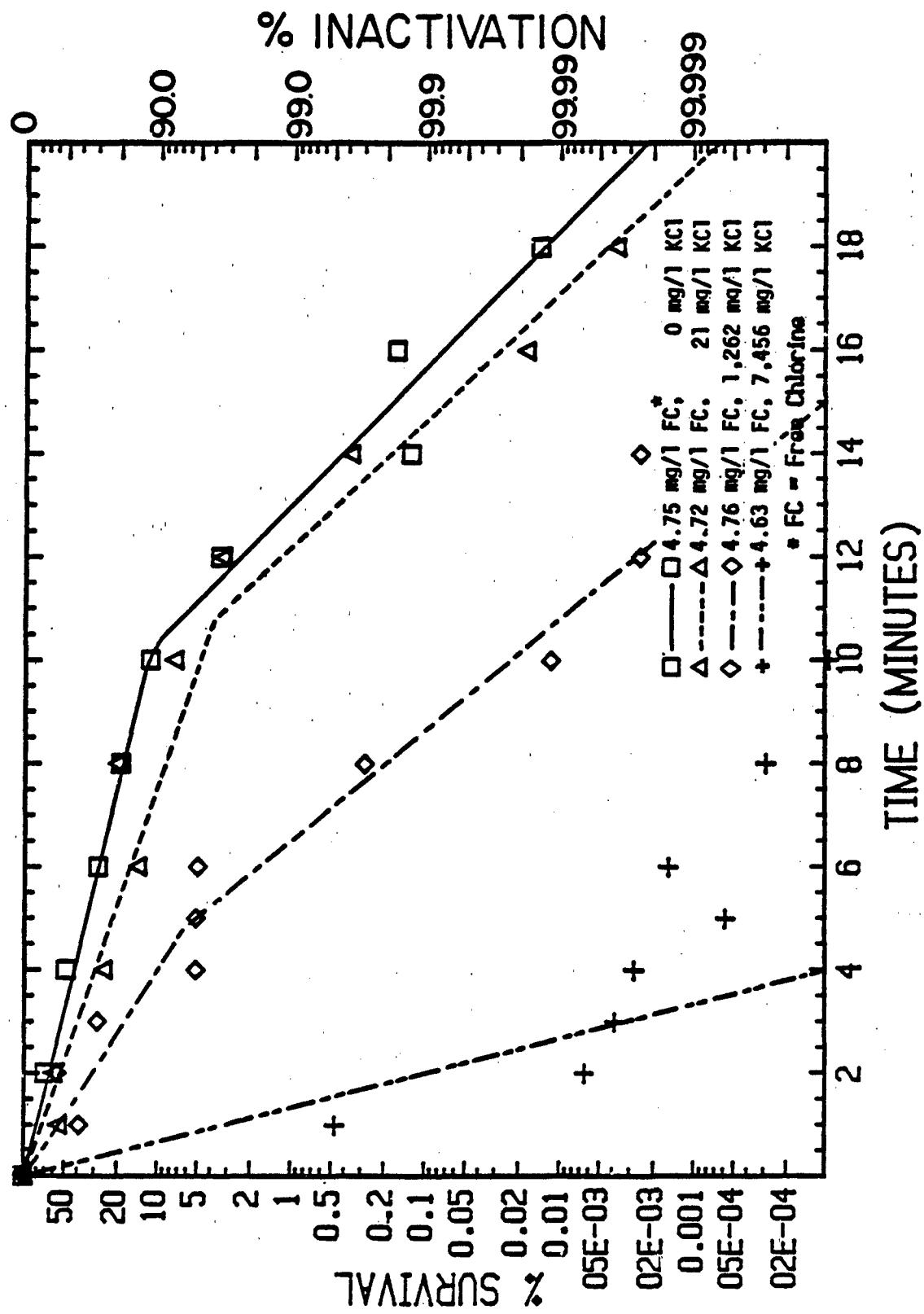


FIGURE A9. INACTIVATION OF POLIOVIRUS 1 AT 5°C IN BORATE-BUFFERED PURIFIED WATER AT pH 10.0 BY APPROXIMATELY 4, 63-4,76 MG/L OF FREE CHLORINE IN THE PRESENCE AND ABSENCE OF KCL



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Abstract Continued - Dr. Gerald Berg (Univ. of Cincinnati) (Proj. No. 3E1-6278-7A878)

increased the poliocidal effectiveness of FC by 1400%.

At 5°C, poliovirus 1 was inactivated by FC at pH 9.0 more than 9 times more rapidly in nonbuffered tap water than in non-buffered purified water suggesting that KCl with or without other ions in tap water potentiated the virucidal effectiveness of FC.

Potassium chloride did not potentiate the poliocidal effectiveness of FC at pH 9.0 to nearly the degree in nonbuffered tap water that it did in non-buffered purified water suggesting that ions present in tap water potentiated the virucidal effectiveness of FC.

FC inactivated poliovirus 1 at pH 9.0 more than 3 times more rapidly in borate-buffered (0.05M) purified water than in nonbuffered purified water suggesting that the buffer ions potentiated the virucidal effectiveness of the FC. Clearly, disinfection studies should not be done in buffers without first determining the virucidal potentiating effect of the buffers.

Potassium chloride potentiated the virucidal effectiveness of FC in 0.05 M borate buffer to a lesser degree than in nonbuffered purified water further indicating that buffer ions potentiated the virucidal effectiveness of FC and that a maximum ion effect exists.

Potassium chloride, at a level 1, 262 mg/L, potentiated the virucidal effectiveness of FC at pH 4.5 in phthalate-buffered purified water, but to a lesser degree than it potentiated the virucidal effectiveness of FC at pH 9.0 in borate-buffered purified water.

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